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"Modified Double Basin Solar Still Performance Analysis By Using Multilayer Absorber Plate"

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Abstract: Solar still is used to convert brackish or dirty water in to the pure water. It is widely used in remote or arid areas in which pure water is noteasily available. The double basin solar still with multilayer absorber plate inside is fabricated and compared with the conventional solar still. From the experiment it has been observed that the modified double basin solar still with multilayer absorber plate has more productivity as compared to the conventional solar still. Also the efficiency for both the solar still was calculated.

Keywords: Solar still, desalination, multilayer, double basin, absorber plate.

I. Introduction

Solar still is generally used to convert the brackish or saline water into pure water with the use of solar energy. Only 3% of pure water is available as a drinking water from the all available resources and remaining is in the form of ice berg, brackish water or as saline water. This available water get polluted due to development of human lifestyle, industries and development of the country. Due to impure water some water born deices are placed which is harmful to the human society such as cholera, typhoid, diarrhea, hepatitis E, etc.for the solution of drinkable water researchers has beendeveloped systems to convert the impure water into a pure water such as reverse osmosis, vapor compression, electrolysis, solar desalination. Except solar desalination all systems are governed by electricity which is developed by coal or fossil fuel power plant. These plants are depending upon the nonrenewable sources and also generating the pollution. The prizes of the non-fossil fuel are increasing day by day this may leads the country towards economy crisis and the pollution may leads the world towards global warming. Distillation of brackish or saline water, whereverit 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 stagewater 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.

Problem Statement

Necessitate the Enhancement in the output of a Solar stilland reduction in the required Area of basin. Because oflower Productivity as well as Efficiency of the Solar Still, it is not used commercially. Improvement in the performance of solar still is required.

II. Objective of Work

- To enhance the productivity of the Multilayer solarstill.
- Reduction in the area required for the sameproductivity.

To observe the effect of water depth on the multilayer absorber plate in Multilayer solar still.

III. Literature Survey

Modi, K.V., Nayi, K.H. and Sharma, S.S., (2019) inspired to improvement in spherical basin solar still by integrated with parabolic reflector. The spherical basin solar still has been developed and performance has been investigated for various water mass such as 1 L, 2 L, 3 L, 4 L and 5 Lin basin. The daily yield of 3.5409 L/m^2, 4.7860 L/m^2, 6.7174 L/m^2, 7.4744 L/m^2 and8.2596 L/m^2 was obtained for 1 L, 2 L, 3 L, 4 L and 5 L water mass in basin respectively. The daily average efficiency of spherical basin solar still was obtained 19.56%,23.92%, 30.83%, 34.49%, 39.06% for the
1 L, 2 L, 3 L, 4 L, 5 L water mass in basin respectively.

From experimental results, it has found that the distilledoutput increases with increase in mass of water in basin.[1]

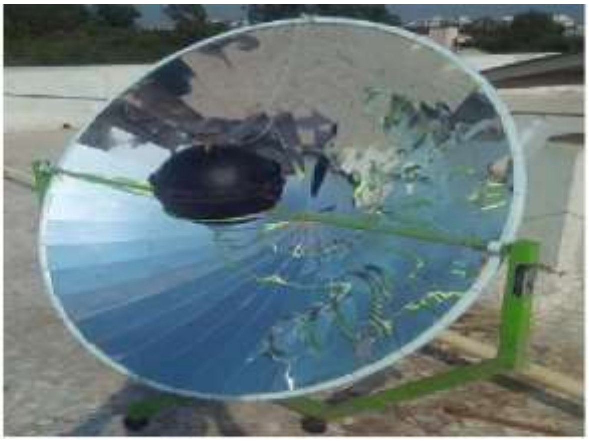

Figure Error! No text of specified style in document.**.1 Experimental setup of SBSS along with parabolic reflector[1]**

Panchal, H.,(2019) et al. reviewed on the tubular solar still to enhance the distillate output. It covers the working principle and several metrological parameters like the temperature of the water, solar intensity, glass cover temperature etc. Various techniques to improve the distillateoutput of tubular solar still also included in the review paper. [2]

Vigneswaran, V.S., (2019) work on integration of latent heat energy storage mediums (phase change materials (PCM)) in the conventional solar stills to extend the water yield ability after the sunshine hours. In this investigation they compares the thermal performance of three same-sized passive solar stills, i.e.,conventional solar still (Still 1), still with single phase change material (Still II), still with two phase change materials (Solar III). The two PCMs used in still III are chosen in such a way that both the PCMs have almost same latent heat storage capacity, but different phase change temperature range. PCM1 and PCM2 used in solar still III have the phase change temperature (PCT) range of 58.03 °C–64.5 °C and 53.05 °C–62 °C, respectively. The major inference from the experiments conducted is that, when multiple PCMs are employed in a still, selection of PCM with appropriate PCT range is very important. PCM1 should start discharging the stored latent heat energy stored once the solar radiation gets diminishing and PCM2 should start to release the heat whenPCM1 has almost discharged the entire stored energy. By this way, the time of yield canbe prolonged. In theresults, the thermal performance of Still I, II and III was analyzed in terms of hourly yield per day and exergyefficiency. The yield of Still I was 3.680 L/m^2/day while the yield of Still II and III were 4.020 L/m^2/day and4.400 L/m^2/day, respectively. The exergy efficiency of still I, II and III were found to be 3.92%,3.23% and3.52%, respectively.[3]

Singh, A.K., (2019) et al. reviewed specially designed singlebasin solar stills to find out the performance based on its efficiency, productivity and economy. Various novel modelshave also been observed for better view of relative performance among all solar stills to establish its clear utility indications as well. The observations have been concluded with broad perspective and some recommendations have also been suggested for the futurescope for developing new designs to meet the possible challenges.[4]

Elbar, A.R.A., Yousef, M.S. and Hassan, H., (2019)compiled energy, exergy, exergoeconomic and exergoenvironmental (4E) assessment of new integration of solar still with photovoltaic module (PV) is performed. This new integration is based on installing the PV module overthe back side of the solar still while its output electrical power is converted directly to thermal heat to heat the saline water in the basin. The main advantage of such integration is that it does not occupy an extra area more than the land area occupied by the solar still. Furthermore, this integration makes the PV as a reflector that transferring its reflected solar energy to the solar still basin. Four systems of solar stills are examined and compared; conventional solar still (CSS), solar still with photovoltaic module (CSS þ PV), solarstill with PV and black steel wool fibers in the basin(CSS þ PV þ BSWF) and solar still with PV used as a reflector only (CSS þ PV reflector).Results indicated that the inclusion of CSS þ PV, CSS þ PV þ SF, and CSS þ PV as a reflector in solar still enhances the modified still energy efficiency by 10%, 31.48%, 43.16%, respectively compared to CSS. Whereas, the corresponding value of exergy efficiency is also enhanced by 30.72%, 49.14%, and680.7%,respectively. The application of PV with solar still was found ineffective in terms of energy payback time compared to CSS. [5]

Sathish, D., Veeramanikandan, M. and Tamilselvan, R., (2019) compared performance of conventional solar still with that of modified solar still in which metal matrix structures are used as a sensible heat storage media, thus it saves the excess energy produced during day time and utilizes the sensible heat energy from the metal matrix structure at the evening or nighttime. The metal matrix structure is immersed in the middle of the basin where salinewater is stagnates.In the solar still, during less hours of solarintensity, the sensitive heat was released from the metalmatrix. Attempts are made to use the maximum amount of solar energy incident and to use the sensibleheat accumulated in the structures of the metal matrix structures. Its productivity and efficiency arecompared to the traditional still under the similar climatic circumstance. It is observed that average stillproductivity and efficiency in the modernized still with metal matrix increases significantly with less costfor this alteration because it is very cheap and effortless to access.[6]

Mu, L., (2019) et al. worked on refraction-based methodology for concentrating sunlight augmented with conventional solar still. The Fresnel lens (FRL) wasintegrated with a single-basin, singleslopesolar still to refract the incident sunlight to a focal point that was constantly located on the basinbottom. Due to the introduction of the FRL, two major impressive findings were observed. With the increased heat input and the high heattransfer rate, the utilization of FRL achieved a significant pure water production enhancement (L/m^2/day)ofabout 467%, as well as a significant daily efficiency (h) improvement of about 84.7%, compared to aconventional system without FRL. It was also found that increasing dw

6. For batter comparison two basin Simple and doublebasin have been fabricated.
7. Both the basins are directly exposed to the sunlight.

8. Due to heat water gets evaporated in the basin and condensed at the inner surface of glass cover whichis drawn downward due to slope of the glass cover and collected in the collecting channel.
9. This collected water gets out by outlet pipe given tothe channel and collecting in the bottle which is measured with measuring Jar.
10. Hourly temperature, Radiation data, and Distilledwater collection have been recorded manually.
11. Calculate the efficiency from the collected data andcompared the Results from the collected data of the systems.
12. Conclude the Results.
13. The instantaneous efficiency of the still is calculated using the formula.

orapplying forced air cooling effect could benefit fromincreasing h.[7]

Gnanaraj, S.J.P., Ramachandran, S. and Christopher,

$$\eta = \frac{M \times h_{fg}}{A \times I \times \Delta t}$$

Experimental Setup

… … … … … … … … … … … … … (1)

D.S., (2017)attempted to optimize the performance of double basin solar still. The dimension of thelower basinwas 100 × 140 cm^2 and the dimension of the upper basinwas 100 × 100 cm^2. So the lower basin had100 × 200 cm^2 glass cover in both the sides of the still to receive direct sunlight. Further external energy sourcessuch as reflectors, flat plate collector and mini solar pondwere integrated with the double basin still. The productivityof single basin still, double basin stillwith no external modifications, double basin still with reflectors, doublebasin still with reflectors coupled with flat plate collector and mini solar pond was 2745, 4333, 5650 and6249 mL/day respectively. Theproductivity of double basin still, double basin still withreflectors and doublebasin still integrated with flat plate collector and mini solar pond was 57.83%, 105.8% and127.65% respectivelyhigher than the single basin still. The above modifications increased the performance of lower basin and upperbasin. But the relative contribution of lower basin improved from 29.75% to 35.22% and to 40.6%.[8]

Experimental Process

1. Design the Experimental setup in CAD Software
2. Fabricate the Experimental Setup as per Design
3. Inner surface of the Basins are painted black toabsorb the maximum solar radiation
4. Assemble the Components of Setup and Equippedwith measuring points.
5. Put temperature sensors at inner surface of glasscover and in the Basin water.

Experimental setup of double basin multilayer solar still has been made-up of galvanized iron steel with inner surface coated black to absorb the maximum solar radiation during the day period. The inclination angle for condensing glass cover is 23° with horizontal. The double basin solar still has top and bottom basin in which bottom basin is filled with water and then closed with top glass cover and on this glass cover again water has been filled for the top basin thencovers the top with glass cover. Both the basin has inclination of same and collecting channel for collecting the condensing water which coming from the inner surface ofthe glass cover. This whole basin is put on a stand with certain height. During the clear sunny day, the solar still is directly exposed to the sun light towards northern facing. During the day period it absorbs the maximum solar radiation. Because of it was fully air tight basin the water gets evaporated at the lower temperature around 55-60°. The multilayer absorber plate made such that the top plate passesthe solar radiation to the bottom plate from its holes. The radiation absorbed by absorber plates and gets heated up. Because of this heat water gets convection heat from the plates and heated by rise in temperature. After some time because of temperature difference between bottom of the glass cover and surface of water, water gets evaporated and condensed at the inner surface of the glass cover. Because ofinclination droplets of water move towards downwards and get collected in the collecting channel. During the condensation in the bottom basin water of top basin receive this latent heat of evaporation from the bottom vapour and gets heated up by direct sunlight and evaporation latent heat.

After sometime this water start evaporating because of increase in temperature difference between glass inner surface and water surface. Vapour of water lose their heat at the inner surface of the glass cover in the environment by convection and get condensed. These condensed dropletsmove towards downwards with inclined surface of glass cover and collected in the collecting channel. The collected water is collecting out by supporting pipeline outside the basin and collected in the bottle then it was measuring in themeasuring jar. During the experiment temperatures data at multiple location and solar radiation have been measured hourly.

Figure 2 Experimental Setup

IV. Result & Discussion

maximum solar radiation has been observed during the peak

Figure 2 shows the behavior of different temperatures during the experiment with 1cm water depth in the double basin solar still and in Conventional Solar still. From the Figure 2 it has been observed that the solar radiation intensity is increased gradually from the 10:00am to02:00pm and then after it decreased gradually. The period of 12:00pm to 02:00pm.The maximum temperature has been observed with Vapour temperature inside the basin and it followed by water temperature, glass temperature and air temperature. The temperature difference between inner surface of glass cover and water temperature is noted maximum at 01:0pm to 02:00pm which increasing the evaporation of water inside the closed basin.

						Ti	me (hr)

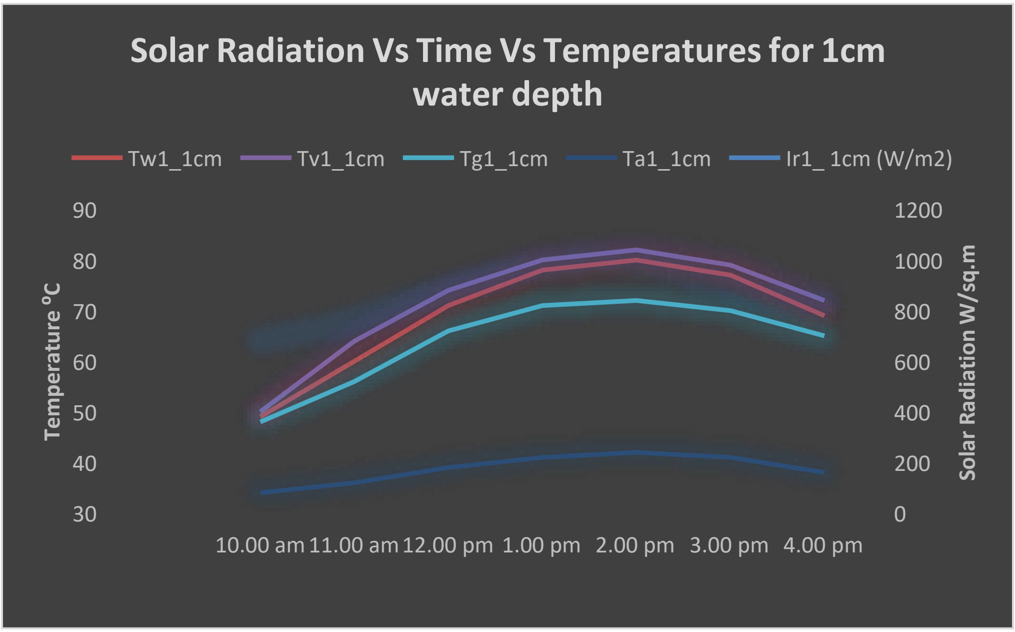

Figure 2 Effect on Temperature behavior with solar Radiation and Time for 1cm water depth in Double basin solar still

Figure 3 shows the temperature behavior of conventional solar still with change in solar radiation with respect to time. The lowest temperature observed with the ambient air temperature and the highest temperature observed with thevapor temperature inside the basin during the experiment.

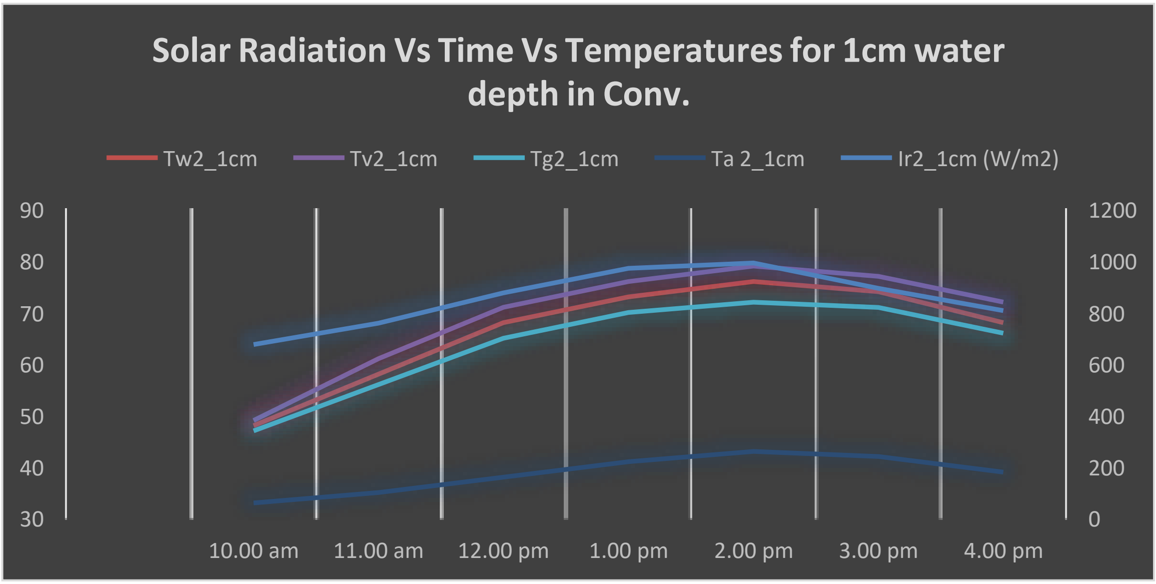

Figure 3 Effect on Temperature behavior with solar Radiation and Time for 1cm water depth in Conventional Solar still

Figure 4 shows the daily productivity with hourly observation of collected pure water. From the Figure 4 it has been observed that the productivity of the double basin solar still is higher as compared to the conventional solar still. The highest productivity in both solar still is recorded at 01:00pm - 02:00pm. The productivity of both the solar stills were increasing and decreasing gradually from the pickhour time.

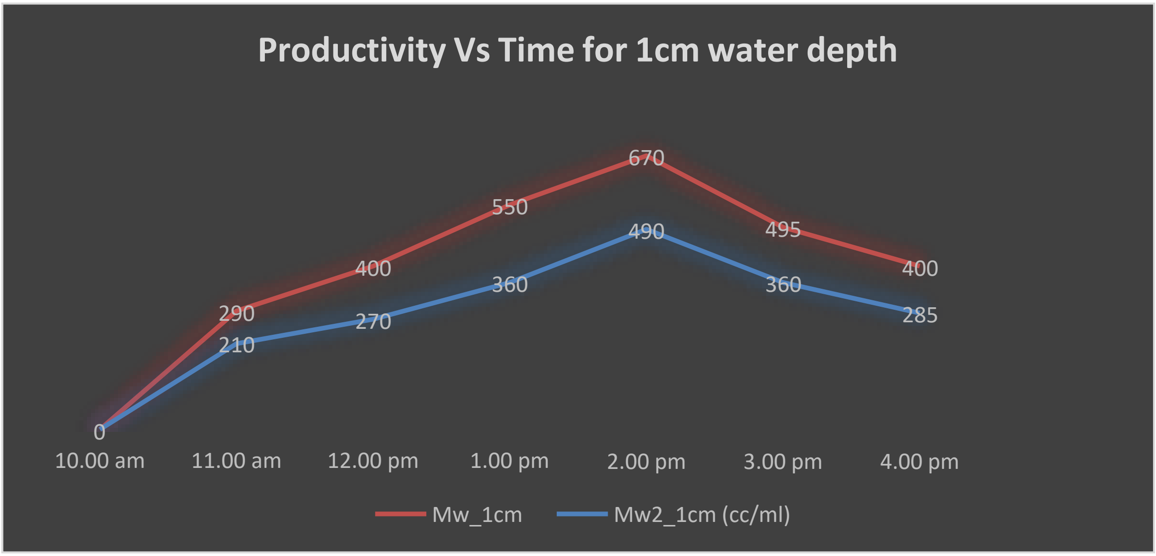

Figure 4 hourly Productivity of double basin solar still

V. Conclusion

From the Results it has been conclude that the double basin solar still with multilayer absorber plate give the highest productivity as compared to the conventional solar still. The maximum productivity per hour has been observed 670 liter.

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