Experimental Evaluation of a Solar Still with Absorber Material

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Abstract: **- Fresh water is one of the basic requirements of human life. Due to the rampant growth in population and high pace of industrial growth, the requirement for fresh water has increased considerably. Solar still is one of the good options for getting fresh water in coastal areas with practically no electricity input and has no problems as concerned with pollution of any kind. For getting the fresh water we have performed experiments on a modified solar still (MSS) which comprises of internal glass reflectors and cotton absorber and its results are compared with conventional solar still (CSS). The result shows that the fresh water productivity of modified solar still is 2.5 times greater than the conventional solar still. The maximum distillate was obtained at 2:00 pm for both MSS and CSS. The maximum accumulative productivity obtained was 980 and 405 for MSS and CSS, respectively. The maximum temperature of the water in MSS and CSS were 48ºC and 51ºC, respectively.**

Keywords **– cotton absorber, inclined type solar still, flat basin with reflectors, water spray nozzle desalination, internal reflectors.**

I. INTRODUCTION

Water is basic need for civilization and it necessary in all part of human life [1]. Humankind is dependent on ponds, lake, river and underground water source to fulfill its requirement of fresh water. Solar energy is a natural source of energy and it can also be used for the distillation of water [2]. Solar still is one of good options for the production of fresh water at a low cost because the solar still basically work on sun light [3, 4]. The performance of solar still depends on many factors such as intensity of solar radiation, humidity, wind velocity etc [5]. Solar still system is the solution for cleaning the saline water in remote areas [6]. Solar still is a nature friendly system to produce fresh water at sustainable cost [7]. In our planet Over 97.5% of the total stored water is saline and 1% is clean, which is continuously decreasing [8]. The rapid industrial growth increases the demand of fresh water. In many countries less rainfall leads to water problem for drinking and other needs. The sea water contains many type of impurities such as salt, carbons and chemicals, we can easily solve this problem with the help of solar still system at very cheap rates.

II. LITERATURE REVIEW

For improving the performance of a solar still various modifications were incorporated in conventional solar still by various researchers which are discussed in this section.

Omara and Eltawil studied on hybrid of solar dish concentrator having a boiler and simple solar collector for brackish water desalination. The results indicated that the daily average of distillate water was 6.7 l/m^2 for solar dish concentrator (SDC) with preheating of brackish water. The daily average efficiency of SDC and CSS was 68 and 34%, respectively. [9].

Eltawil enhanced the solar still performance with a flat plate solar collector, spraying unit, perforated tubes, external condenser and solar air collector. In experiment, the modified solar still (MSS) productivity was more than the CSS by 51–148% depending on the type of amendment. The use of external condenser with solar still increased the productivity by 51%. The use of circulated hot water in passive and active sprays without condenser led to increase the developed solar still (DSS) productivity by 56% and 82%, respectively [10].

Naga performed experimental investigations on performance of a single basin solar still using different energy absorbing materials. Solar energy can be used to produce fresh water directly in a solar still. One way to improve the energy utilization is to store the energy during sunshine times of higher solar incidence for later use of necessary needs. Efficient storage technologies are required to store energy for twenty four hours cycles to meet energy demand. Energy storage would enable to power generation for night periods and it helps match the generation and demand peaks. [11]

An experimental study of a solar water desalination using an air bubble column humidifier is investigated by El-Samadony and Abdo. The results showed that the daily productivity, efficiency and gain output ratio are 21 kg, 63% and 0.53, respectively. At inlet, water temperature was 62 °C [12].

Huang introduced a spiral multiple-effect diffusion solar still coupled with vacuum-tube collector and heat pipe. The measured solar distillation efficiency is 2.0 to 3.5. The performance enhancement results mainly from the lateral diffusion process in the spiraled still cell. The test results of a

14-effect unit coupled with vacuum-tube solar collector showed that the highest daily pure water production is 40.6 kg [13].

Omara enhanced the stepped solar still performance using internal reflectors. A comparative study between modified stepped solar still with trays (5 mm depth and 120 mm width) and conventional solar still was carried out to evaluate the developed desalination system performance under the same climate conditions. Results show that the daily efficiency for modified stepped still with and without internal reflectors and conventional solar still is approximately 56%, 53% and 34%, respectively [14].

Chain used a residual heat-powered three-effect tubular solar still to analyze the characteristics of heat and mass transfer on normal-pressure and fixed-temperature heating in and fixed-power heating, and also to figure out the analysis of parameters of water production by desalination. The experimental results show that there exists a direct-proportion linear relationship between the temperature and water production by desalination at normal pressure, that at negative pressure, the water production is several times as large as that at normal pressure [15].

Somanchi presented a study on the performance of solar water distillation using Phase Change Materials. In the experiment Magnesium Sulfate Heptahydrate ($MgSO_4$ $7H_2O$), Sodium Sulphate (Na_2S $7H_2O$) are used as phase change material and Titanium oxide as a nano-material for energy storage material. Among these energy storage materials Magnesium Sulfate Heptahydrate (MgSO4 7H2O) improves the efficiency of solar water distillation [16].

After studying the literature, a modified solar still (MSS) is designed and fabricated which consists of internal reflectors and black cotton cloth as absorber material. The details of which are discussed in the next section.

III. MATERIALS AND METHODS

The MSS consists of internal reflectors and black cotton cloth as absorber material. The body of modified solar still (MSS) is manufactured by GI sheet metal with a thickness of 2 mm.

The dimensions of modified solar still are as follows:

Area of basin = 103 cm × 96 cm

Area of reflector = 60 cm × 40 cm

Area of absorber = 93 cm × 76cm

In this setup we used internal reflector for enhancing the effect of solar radiation. The internal reflector reflected sun rays on absorber material and base water and increase the productivity of solar still. The inner surfaces of still are painted with black colour paint to increase the absorptivity. A toughened transparent glass cover thickness is 4 mm is used to place over the inclined surface of the solar still. The transparent glass cover is made to incline at 29° as per the position of Bhopal. The experimental location was Radharaman Institute of Research and Technology, Bhopal, Madhya Pradesh.

Before starting the experiment, the water was filled in the basin upto a height of 2 cm. The basin was covered with toughened glass, after that the entire set up was sealed with a leak proof material. The water gets heated due to solar radiation and some water sprayed on absorber with a special arrangement, water gets evaporated and comes in contact with glass. It is cooled with the help of atmospheric air, this cooled droplets flow downward through inclined glass and gets collected in the collecting jar via the channel.

During the experiment, intensity of solar radiation, MSS glass temperature, CSS glass temperature, MSS basin water temperature, CSS basin water temperature, atmospheric temperature, atmospheric humidity, MSS basin humidity, CSS basin humidity, wind velocity on MSS Glass and wind velocity on CSS glass were measured. This all values help the calculation of accurate resultant. In last stage of experiment we collected the condensate from the modified solar still and compared the performance with conventional solar still (CSS). Figure 1. shows the experimental location and instrumentation.

Figure 1. Experimental set up with measuring instruments

IV. RESULTS AND DISCUSSION

After performing the experiments on MSS and CSS, many observations were made which are discussed in this section.

Figure 2 shows the graphical analysis of solar radiation with respect to time. The solar radiation is 980 W/m^2 in 10:00 am. It increases continuously from 10:00 am to 2:00 pm. The highest solar radiation was recorded as 1265 W/m^2 at 2:00 pm and after that solar radiation decreases.

Figure 3 shows the hourly productivity with time of CSS and MSS. The maximum productivity of fresh water was obtained as 135 and 65 ml for MSS and CSS, respectively at 2:00 pm. The maximum solar radiation also occurred at 2:00 pm which

was 1265 w/m^2. The experiment shows the fresh water productivity of modified solar still is 2.42 times more as compared to conventional solar still.

Figure 4 shows the glass temperature of CSS and MSS with time. The temperatures were recorded on hourly basis. The glass temperature of CSS and MSS increases continuously with time and reached to a maximum value of 42°C and 45°C respectively at 2:00 pm.

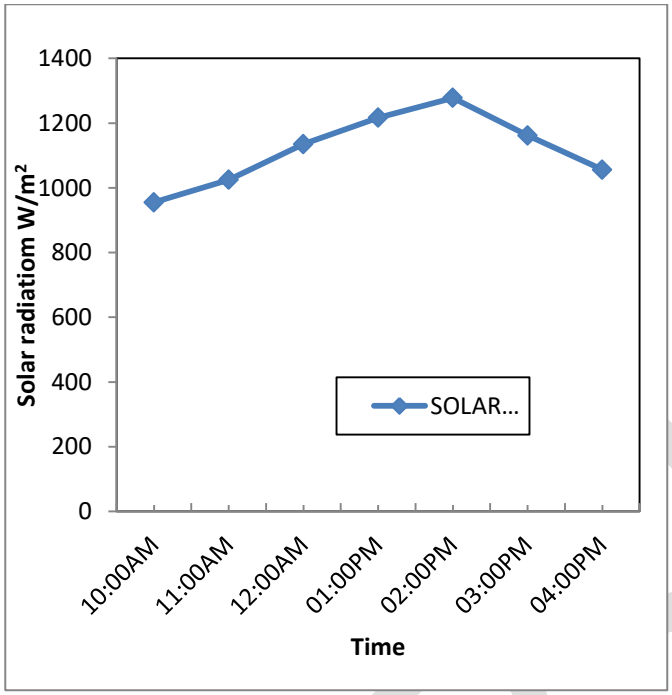

Figure 2. Variation of solar radiation with time

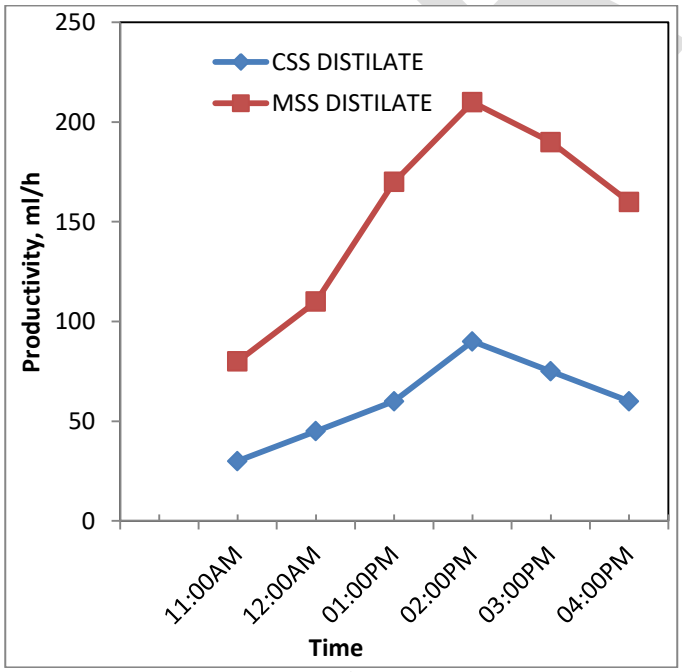

Figure 3. Variation of hourly productivity with time

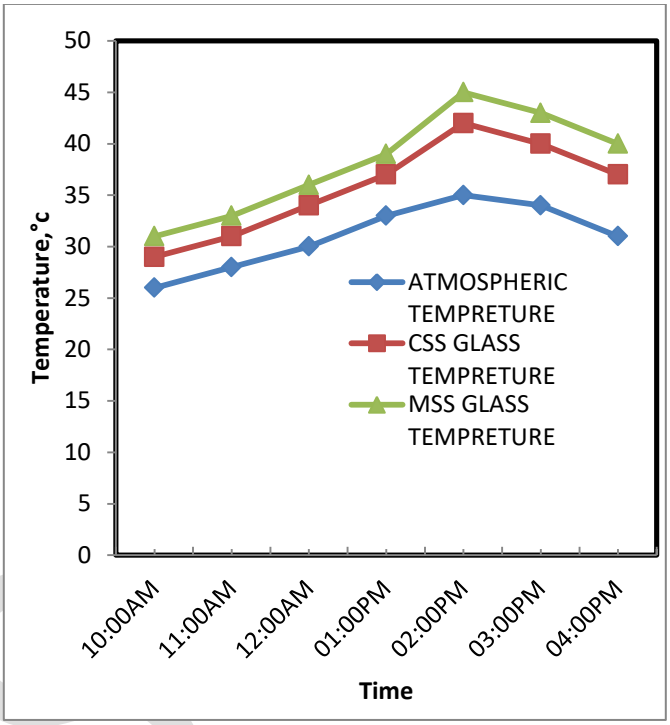

Figure 4. Variation of temperature with time

V. CONCLUSION

In the present work, a modified solar still has been designed and fabricated with internal reflectors and cotton absorber. The parameters like glass temperature, basin water temperature, atmospheric temperature, solar radiation, wind velocity, humidity were measured. The performance of the MSS with CSS was compared. Following conclusions were drawn after the analysis.

1. During the experiment the maximum solar radiation of 1285 W/m^2 at 2:00 pm.
2. The accumulated productivity of 980 ml 405 ml was observed for MSS and CSS, respectively. Thus, the productivity of MSS was about 2.42 times that of CSS.
3. Maximum temperature of basin water was found to be 48°C and 51°C for MSS and CSS respectively. The maximum ambient temperature was found to be 39°C.
4. A maximum humidity of 93.2% and 91.6% for MSS and CSS respectively.

It can be concluded that the present setup of modified solar still is much better compared to conventional solar still. This arrangement can be used for water purification in remote areas also where electricity is not available.

REFERENCES

[1]. Aghigh Arash, Alizadeh Vahid, Wong H.Y., Islam Shabiul Md., Amin Nowshad, Zaman Mukter, "Recent advances in utilization of graphene for filtration, desalination of water"Desalination365 (2015) pp 389-397.

[2]. Sathyamurthy Ravishankar, Dharmaraj Vijayakumar, El-Agouz S.A., "Experimental analysis of a portable solar still with evaporation and condensation chambers"Desalination 367 (2015) pp 180-185.
[3]. Wong Z., Dou B., Zhang L., Zhang G., Lou Z., Hao ZZ "Effective desalination by capacitive deionization with functional graphane nanocomposite as noval electrode material" Desalination 299 (2012) pp 96-102.
[4]. Hyek Al Imad, Badra O Omer, "The effect of using different designs of solar stills on water disalination" Desalination 169 (2004) pp 121-127.
[5]. Kabeel A.E., El-Agouz S.A. "Review of researches and developments on solar stills" Desalination 276 (2011) pp 1-12
[6]. Cappeletti G.M. "An experiment with plastic solar still" Desalination 142 (2002) pp 221-227.
[7]. Elango T., Murugavel Kalidasa K. "The effect of the water depth on the productivity for single and double basin double slope glass solar stills" Desalination 359 (2015) pp 82-91.
[8]. Ehrlich P.R., "Human appropriation of renewable fresh water" science 271 (1996) pp 785-788.
[9]. Omara Z.M., Eltawil Mohamed A. "Hybrid of solar dish concentrator for brackish water desalination" Desalination 326 (2013) pp 62-68.
[10]. Eltawil Mohamed A., Omara Z.M. "Enhancing the solar still performance using solar photovoltaic, flat plate collector and hot air"Desalination 349 (2014) pp1-9.
[11]. Gugulothu Ravi, Somanchi Naga Sarada, Devi R Sri Rama and Banoth Hima Bindu "Experimental Investigations on Performance Evaluation of a Single Basin Solar Still Using Different Energy Absorbing Materials" Aquatic Procedia 4 (2015) pp 1483 – 1491.
[12]. El-Samadony Y.A.E., Abdo Ahmed "Solar water desalination using an air bubble column humidifier" Desalination 372 (2015) pp 7-16.
[13]. Huang Bin Juine, Dai Han Yi "Spiral multiple-effect diffusion solar still coupled with vacume-tube collector and heat pipe" Desalination 362 (2015) pp 74-83.
[14]. Omara Zm, Kabeel A.E., Younes M.M. "Enhancing the stepped solar still performance using internal reflector" Desalination 314 (2013) pp 67-72.
[15]. Chain Zhili, Yao Yang "Analysis of the characteristics of heat and mass transfer of a three-effect tubular solar still and experimental research" Desalination 330 (2013) pp 121-129.
[16]. Somanchi Sarada Naga, Swathi Sri Lalitha Sagia,Thotakura Ashish Kumar,Sai Phanindra Kakarlamudi Dinesh, Parik Ajay **"**Modelling and Analysis of Single Slope Solar Still at Different Water Depth" Aquatic Procedia 4 (2015) pp 1477 – 1482