Design, Modification and Comparative Study of a Solar Still to Enhance Its Efficiency by Using External Active Element

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Abstract: This work shows a modified design of solar still with magnifier, which is placed at the top of the inclined glass. The evaporation rate of water was increased by increasing the base temperature with the help of a magnifier. The desalination process on the modified solar still was carried in Mumbai (19.0760° N, 72.8777°E) India. Different variables were measured on an approximately hourly basis. Increase in the output of modified still was found to be 43.67 % when compared with the simple still with 0.27m^2 area.

Keywords: Solar Still, Desalination, Magnifier

I. INTRODUCTION

Solar stills are classified into passive and active equally as single and multi-stage categories supported all totally different applications. Passive systems area unit those that receive no energy kind non-solar energy supplies whereas active systems receive some energy from associate degree external source more to the common energy to spice up the temperature and consequently the evaporation rate of un-distilled water. This external energy is provided by solar collectors or the thermal energy wasted in industrial units. Commonplace single stage solar stills utilize the system's energy input only once. However, multi-stage systems area unit specifically designed to use the warmth of condensation of the vapor another time, so as that this energy is used for evaporation a number of times. Zaki et al.[1] researched the incorporation of a functioning single inclined sun oriented gatherer with a level plate authority and found that the most extreme yield increment was up to 33%. While Badran et al.[2] found that the mix of a level plate authority with a solitary sun-powered bowl still builds the consumable water efficiency by a limit of 52%. Singh and Tiwari [3] did the numerical examination of latent and dynamic sun-powered stills execution. Their numerical estimation demonstrated the day by day rate of creation with an expansion in water profundity, distillate diminished. Kumar et al.[4] annual execution of the dynamic sunlight based was still exhibited. Their expository investigation phrases demonstrated that yearly yield diminished with an expansion in yield Water profundity. Tanaka and Nakatake [5] have arranged a totally one of a kind conservative various impact dispersion type star as yet comprising of a heat pipe sun-based gatherer and assortment of vertical parallel parcels to shoulder with saline-drenched wicks to expand the dissipation rate. El-Sebaii [6] gave the transient numerical models for a sun based still with and without stage change material (PCM) underneath the bowl liner of the still. Scientific articulations for temperatures of the still parts and hence the PCM are acquired. The still execution has been explored by the system. Numerical computations are connected, abuse stearic corrosive as a PCM, on run of the mill summer and winter days in Jidda, Asian country. It is demonstrated that in releasing of the PCM, the convective warmth exchange coefficient from the bowl liner to bowl water is multiplied; thusly, the evaporative warmth exchange consistent is misrepresented by twenty sevenths on abuse 3.3 cm of stearic corrosive to a lower place the bowl liner. Ismail [7] contemplated the arranging and execution of a portable hemispherical star still. The outcomes

demonstrated that the everyday water yield from the still ran from 2.8 L/(m^2 day of administration) to 5.7 L/(m^2 day of administration). Lawrence et al. [8] completed numerical reproductions that were approved for a common summer day utilizing their very own tests. Their outcomes demonstrate that the productivity of the water film stream increments as the stream rate increments and is increasingly critical at a more prominent profundity of the bowl. Arunkumar et al. [9] finished up two purposes behind low sunlight based stills profitability. To begin with, the trouble of dismissing dormant build-up heat into the air and, second, the trouble of expanding the dissipation temperature and lessening the build-up temperature. El-bahi and Inan[10] contemplated a close planetary system joined with a reflector in tempered steel and an outer condenser. They revealed 75% effectiveness and 7 kg/m^2 for everyday water creation. Utilizing a twofold gathering spread expanded water creation by roughly 35–77%. El-Sebaii[11] demonstrated that water generation from the aloof sun powered still keeps on expanding with expanding wind speed when the water profundity in the close planetary system is as yet more noteworthy than 4.5 cm. El-Zahaby et al.[12] directed a trial concentrate to enhance sunlight based still execution utilizing a corresponding shower sustaining framework and found that there was gathered efficiency of 6.355 l/m^2.

II. EXPERIMENTAL SETUP

The experimental setup was arranged as depicted in the figure. Thermocouples were placed at various positions as shown in the figure for measurement of the temperatures at various positions. Calibration of the thermocouple was done between 0˚ and 80°C and the solar stills were checked for leakages using a blower, and sealing was done using silicon sealant to prevent leakages of water and water vapor as well Two solar stills were fabricated among which one acts as a simple solar still with no modifications and the other one when coupled with an active element such as a magnifier. The gasket was attached to the glass to ensure the sealing of the solar still. The lens is placed on bottom part of solar still to avoid the focal point to touch aluminium sheet and prevent the sheet from damage. The position of the lens is shown in the figure. Both of the stills were placed under the same atmospheric conditions in the same direction to ensure the increase in the yield.

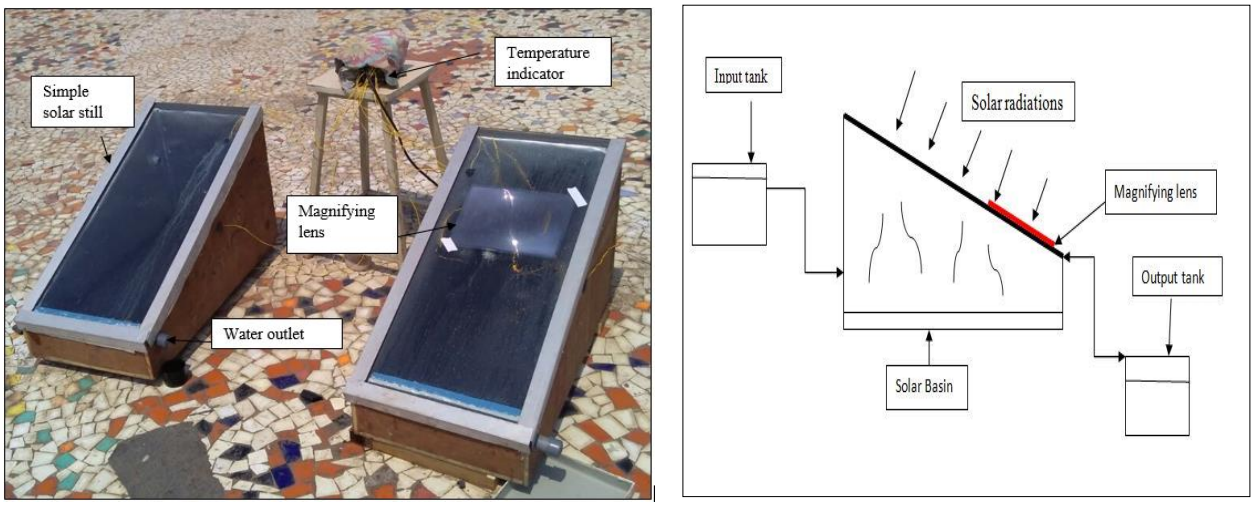

Figure 1: Experimental Setup

Solar still works on the principle of evaporation and condensation. Following flow diagram shows the working process of simple solar still. Brackish water is filled in the black painted basin which is totally insulated. The sloping transparent glass cover is provided at the top. Sun based radiations are permitted to fall on it and the radiations are transmitted through the cover & get consumed operating at a black

painted basin This builds the inner temperature of distiller making the bitter water vanish abandoning all the salt substance, microscopic organisms, infections, and so on vapor of this water begins consolidating on straightforward spread and this dense water turns out as unadulterated water.

Table 1: Specification of the Setup

Sr. No	Technical specification	Dimensions
1	Basin area	0.2736 m^2
2	Thickness of wall (wood + aluminium + insulation)	32 mm
3	Slope of glass	20^0
4	Thickness of glass	8 mm
5	Water depth	15 mm
6	Focal length of magnifying lens	300 mm

III. RESULT AND DISCUSSION

Commencement of taking experimental readings began on 15th March 2018 at 9:30 am IST. The weather forecast for the day was presumed to be cloudy. All temperature values and output values were taken at definite intervals of time. The maximum output obtained was 100ml from the solar still having a lens and a maximum output of 75ml from the simple unit was obtained. Average ambient temperature was recorded to be 34ºC with a maximum and minimum temperature of 36ºC and 28ºC respectively. Readings were taken up to 4:30 pm IST.

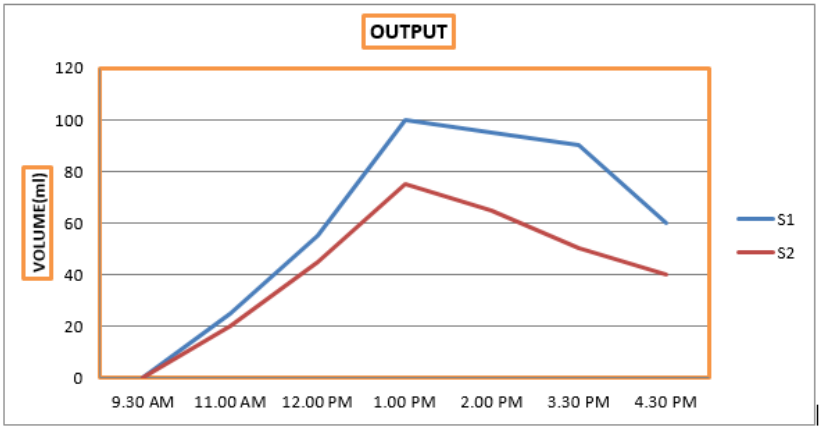

Figure 2: Productivity of solar still on 15th March, 2018

Observational readings commenced on 16th March, 2018 at 10:30 am IST. It was observed that the climatic and weather conditions were seemingly clear. All temperature values and output values were taken at definite intervals of time. A maximum output of 100 ml from the solar still having the lens and 80 ml from the simple unit was recorded. Average ambient temperature for the day was observed to be 35˚C with maximum and minimum temperatures going up to 36ºC and 32ºC respectively. Readings were taken till 4:30 pm IST.

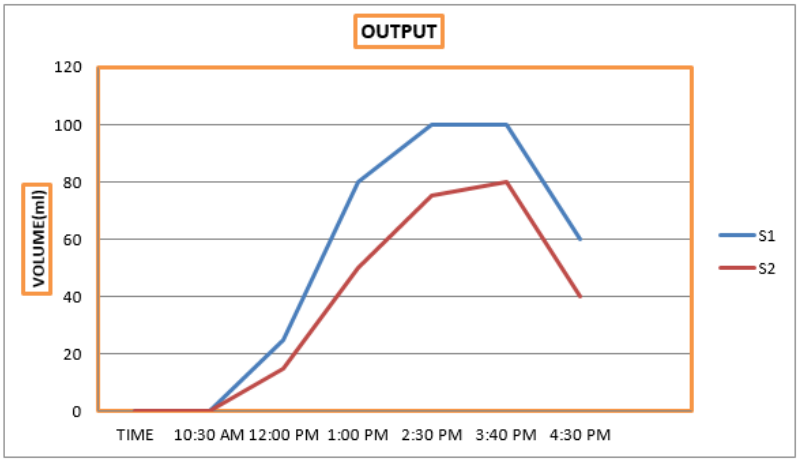

Figure 3: Productivity of solar still on 16th March, 2018

Recording of observations started on 18th March, 2018 at 9:45 am IST. Sunny conditions and clear sky was recorded during the time of taking the observations. All temperature values and output values were taken at definite intervals of time and a maximum output of 145 ml from solar still having the lens and 100 ml from the simple unit was recorded. Average ambient temperature was recorded to be 37˚C with a maximum temperature attaining 40^0C and the minimum was recorded to be 32^0C. Readings were taken up to 4:00 pm IST

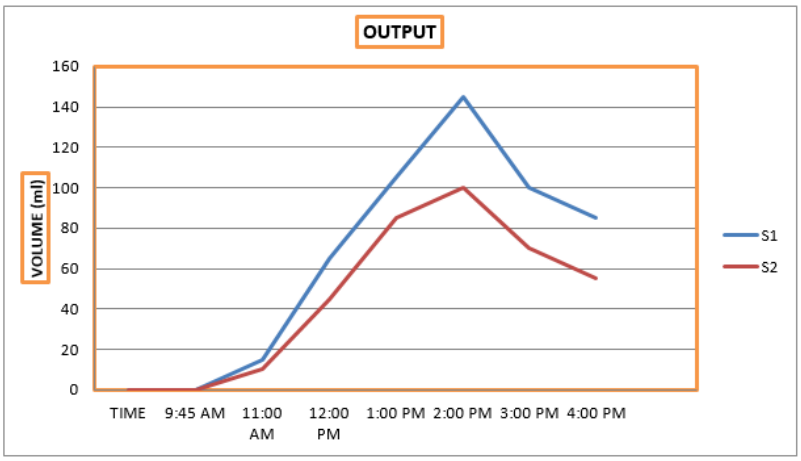

Figure 4: Productivity of solar still on 18th March, 2018

Recording of observations started at 9:00 am IST on the 19th of March. Conditions appeared extremely sunny and humid. All temperature values and output values were taken at definite intervals of time and a maximum output of 150 ml from solar still having the lens and 100 ml from the simple unit was recorded. The average ambient temperature was recorded as 37˚C with a maximum temperature reaching 41^oC and minimum temperature attaining 30^oC. Readings were taken up to 4:00 pm IST.

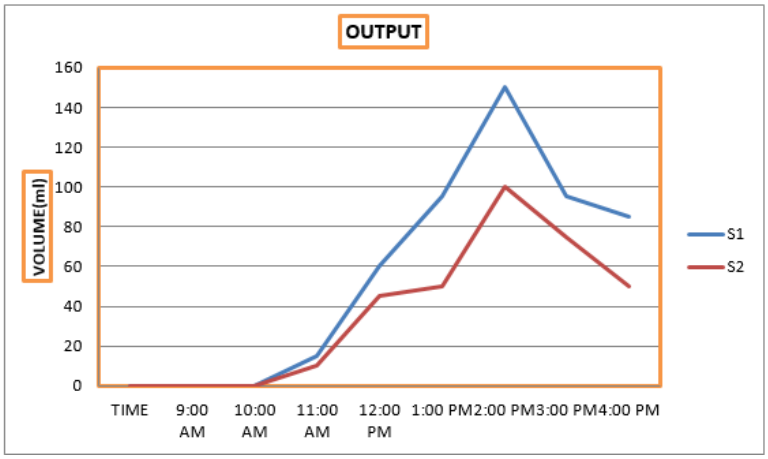

Figure 5: Productivity of solar still on 19th March, 2018

Experimental observations started at 9:00 am IST on the 20th of March. All temperature values and output values were taken at definite intervals of time and a maximum output of 100 ml from solar still having the lens and 75 ml from the simple unit was recorded. The average ambient temperature reached 34˚C with maximum and minimum temperatures being 38^0C and 33^0C during the course of observations taken. Readings were taken up to 4:30 pm IST.

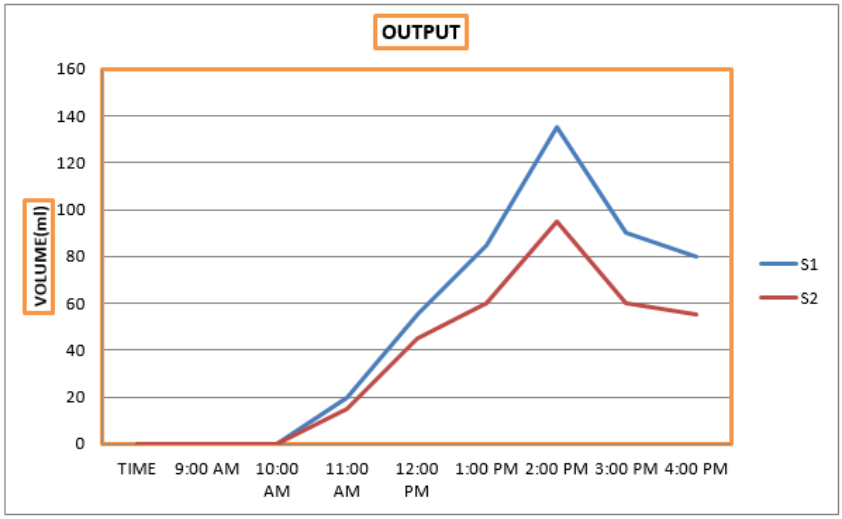

Figure 6: Productivity of solar still on 20th March, 2018

Different variables were measured on an approximate hourly basis such as base inside temperature (T_1 and $T_{1'}$), base outside temperature (T_2 and $T_{2'}$), glass inside temperature (T_3 and $T_{3'}$), vapour temperature (T_4 and $T_{4'}$),wall inside temperature (T_5 and $T_{5'}$),wall outside temperature (T_6 and $T_{6'}$) where T and T' refer to the temperatures of modified still and simple still respectively. The output of solar still with lens was denoted as(S1) and output of solar still without lens was denoted as (S_2) in the observation table. It was observed that the distilled water vapour achieved the maximum temperature followed by the temperature of water at the basin due to the process of convection due to incident solar rays, followed by the temperature of the inner glass where the condensation of the distillate occurs, followed by the outer glass temperature through which the incident rays are transmitted and this is the surface in contact with the surrounding conditions and also the minimum temperature was observed to be the ambient temperature. The maximum yield was obtainable during the time period of 12 pm to 3pm for all the observed days corresponding to a higher solar radiation recorded at the same time span.

The maximum yield obtained through the modified unit was claimed to be 515 ml during the time range from 9:45am to 4:00pm IST on 18th March under sunny conditions at an average ambient temperature of37^0C. Increase in the output of modified still was found to be 43.67 % when compared with the simple still. Due to the providence of a magnifying lens, the incident solar radiations were found to be intensified onto a focal area on the surface of the water stored in the basin of the still and hence we observed that the temperature inside the basin increased in comparison with the still without lens due to which a higher output could be obtained. The following graph shows the daily output of solar stills over the period during which observations were recorded.

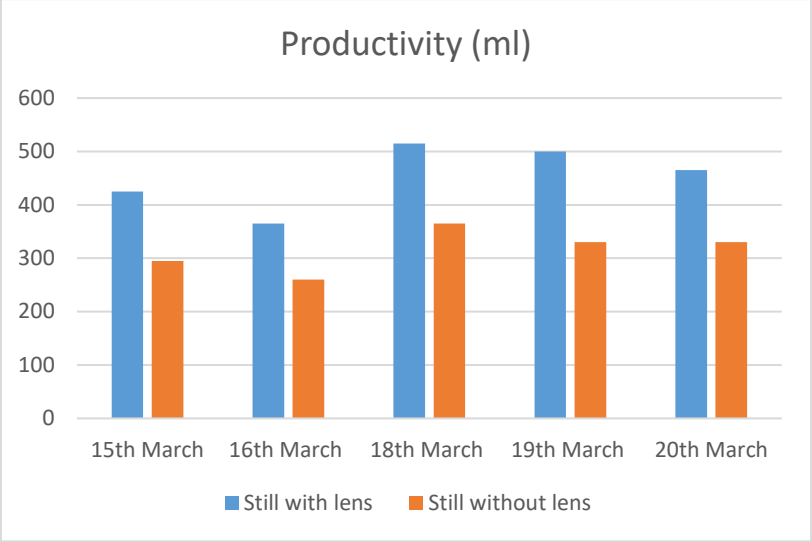

Figure 7: Productivity Comparison

IV. CONCLUSION

In the comparative study, the effect of utilizing a magnifying lens to obtain an increase in the yield of simple solar still was investigated. From the experiment, it could reason that a noteworthy increment in the temperature of the still could be accomplished because of the impact of utilizing an amplifying focal point. The provision of a magnifying lens was found to be most effective when the solar radiations were made to fall directly on the surface of the lens at a time range between 1pm to 3pm IST because the intensity of solar radiations were found to be maximum during the same time span. Along these lines, utilizing a magnifier as an outside dynamic component ends up being a superb choice to enhance the profitability of the still unit. The utilization of magnifier on the sun powered still brought about a critical enhancement in the reachable yield in concurrent correlation with a traditional still.

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical statement: The authors declare that they have followed ethical responsibilities.

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