Performance Study on One Slope Solar Unit Conjoin With Parabolic Concentrator

B. Swapna Babu , G. Murali

Abstract: ***Investigations were performed on one slope solar unit with 17° inclination for condenser. Important components of the experimental setup are: solar desalination unit, parabolic concentrator. Dimensions of the GI basin are 0.7 m length, 0.7 m width, 0.381 m height for the back rectangular face, 0.11684 m height for the front rectangular face. A hollow spherical absorber of 0.65 m diameter containing water is connected to the still. Spherical absorber is heated by a parabolic concentrator whose upper surface is attached with aluminium foil. Due to variation of temperature of water in the absorber and still basin Thermosyphon effect is initiated and water is circulated naturally. All the inside faces of the basin are coated with matt black paint and the experiment was carried for 0.03 m, 0.04m, 0.05m, 0.06m depth of brackish water. The volume of the brackish water was measured by a grading container while the distilled water was measured by a measuring jar. The optimum depth for still attached with absorber is found to be 0.05m and for still without absorber is found to be 0.04 m. Yield collected for still attached with absorber is 2.85 liters and for still without absorber is 2.1 liters. This unit can be installed in and around Vijayawada location as abundant solar radiation is available for nearly nine months in a year.***

Index Terms: Cosmic Intensity, Desalination, Fertility, Concentrator, Absorber, Basin Water Level.

I.INTRODUCTION

Fundamental life source on earth is fresh water and it is essential for all forms of living beings. On earth 97% of water is present as saltwater and remaining 3% is fresh odorless liquid. Less than 1% of fresh odorless liquid is within the human reach. Industrialization and rapid population growth are the main factors to be accounted for the ever increasing fresh water demand. Distillation is one of the important water purification process best suits for the remote and under developing regions. Water desalination can be categorized into two. First is membrane process such as reverse osmosis and electro dialysis and the second is caloric processes which embrace multi-level distillation, multi effect scorching and solar distillation. Solar distillation is particularly preferred for regions which receive high solar intensity and where there is lack of fresh water.Solar distillation is classified into two:

1) Direct solar distillation
2) Indirect solar distillation

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The direct solar distillation units collect the energy from sun to produce the distilled water directly when compared to the indirect solar distillation units.Among the two classified solar distillation units, passive solar distillation stills were recommended as they are economical in providing potable water and indirect solar distillation units are preferred for commercial point of view. Hassannain Gh.Hameed et al. [1] supervised tests on one slope solar unit having basin area 1 m^2. A wire screen mesh is utilized to elaborate the facial area for the evaporation process. Productivity of the solar still was enhanced up to 22.8% when the velocity of air is increased from 0.9 to 4 m/s. The presence of wire screen mesh resulted in an additional enhancement of 20.9% productivity for air velocity of 2.5 m/s. Umar et al. [2] fabricated four identical stills A,B,C,D which are filled with water level of 1.5 cm. Stills A and B were formed of galvanized ferrous sheet while C and D are made of blackened ceramics of 7 mm thickness. Stills B and D are provided with a hand hole of 4 inch diameter to enable the washing way of the residues accumulated in the basin during the process. Solar still A with galvanized iron basin and hermetic seal has greater distillate productivity of 1.66 l/m^2/day when compared to stills B,C,D which have productivity of 1.46,0.97,0.90 l/m^2/day respectively.Gnanaraj [3]fabricated and tested a one slope unit with 11° slope. Hotness transfer to liquid is enhanced by coating the basin surface with black paint and by adding fins. A solar pond which is divided into upper, middle, lower converting zones is attached to the still. Maximum efficiency of 86% was obtained when the still is connected to the lower converting zone of the solar pond. Due to modifications the overall daily efficiency of still increased from 42% to 52%.Balavignesh et al. [4] used mirrors to the sides of the distiller unit and found that the intense liquid hotness increases from 56°c to 62°c and the percentage of distillate productivity has increased up to 26.37%.J.D.Obayemi et al.[5]constructed a one slope unit with floating collector inclination compared its productivity with a still having rigid collector angle. It is found that the daily distillate produced was 1.407 l/m^2day for the still with floating collector inclination and 1.366 l/m^2day for the still with rigid angle collector.Amar S. Sawant [6]compared the instantaneous effectiveness and produce of single and double slope units and concluded that one slope solar unit has high instantaneous effectiveness while the double slope unit has high productivity. Productivity is 545 ml for double slope still and 274 ml for one slope unit whereas instantaneous efficiency is 32.83 for one slope unit and 18.58 for two slope unit. Radwan et al.[7]toted investigations in Egypt on

one slope unit with 20° inclination. Basin is constructed by steel and Suez Canal saline water is purified in the still. Water depth of 0.5 cm is maintained throughout the experiment. Highest average distillate production was obtained with matt black fiberglass as absorbing material which occurred in the month of August with 0.317 l/m^{2}day. The average distillate production for the months of May and June were 0.0055 and 0.102 l/m^{2}day. Phadatare and Verma [8]used Plexiglas as building material for solar unit to beat the problem of corrosion which occurs for the metallic surfaces. For 2 cm level of liquid in still basin, utmost distillate produce is 2.1 l/m^2 day. The experiments were toted for various levels of water and the efficiency is utmost for a liquid level of 12cm. For this unit, the condenser temperature pass the basin liquid temperature when irradiance outpace 550w/m^2. Radiation heat transfer coefficient is higher than the convection heat transfer coefficient and the evaporation heat transfer coefficient is the lofty. SAHOO et al. [9]tried to extract the fluoride from impure water by solar still. Tests were toted to know the amount of fluoride removed for gathered segments. They found that there is fluoride decrement of 92-96% by using solar unit as compared to gathered segments. There is a minute raise in the still productiveness when the volume of impure water input to the still basin is raised. The productiveness are 7.28%, 7.78% and 8.1% for the pool input of 10 L, 15 L and 20 L, respectively. Productiveness of the still raised by 4.69% and 6.05% when the pool is reformed with a blackened base liner and with a blackened base liner with bottom and side thermocol padding, respectively. Bechir Chaouchi et al. [10]attached parabolic concentrator to a small solar still. To appraise the unit's ability, they developed a theoretical model where absorber average temperature and distillate flow rate relates to solar irradiation. Salt concentration in the water used for desalination is up to 35 g/l. A correlation of theoretical and experimental results conclude that variation between them is small regarding the hotness with average relative error of 42% for the pure liquid flow rate. This is due to the deficiency in paraboloid geometry, manual sun tracing and systems tilt during the day.

II. EXPERIMENTAL ARRANGEMENT AND PROCEDURE

The experimental setup of the one slope solar unit attached with external parabolic concentrator is installed at Vijayawada location is shown in the figure. The basin area is 0.7m*0.7m and it is fabricated from 1.2 mm thick G.I sheet. The glass (condenser) is 5 mm thick and 17 ° inclined with the horizontal. Glass rests on the rubber covering which is fixed on the G.I frame. The rubber covering acts as leak proof to the vapor generated in the still basin. The concentrator surface is glued with aluminium foil for good reflection. A spherical absorber as shown in the figure is coupled with the solar still. The spherical absorber gains heat because of the reflection from the parabolic concentrator. The concentrator is manually positioned such that the absorber receives maximum heat from the reflected solar rays. Inlet and outlet pipes from the absorber are connected to the inlet and outlet pipes of solar still. Outlet of the absorber is the inlet of the still and the outlet of the still is the inlet of the absorber. Heat energy is transferred between the impure liquid in the pool and the impure liquid in the absorber due to Thermosyphon affect and the water circulates naturally between the absorber and the still. Water in the still evaporates and gets cooled on the condenser by losing its heat to the condenser. The condensed water is the pure water which trickles down on the back side surface of the condenser and falls in the inclined channel which is provide just below the obstruction provided on the condenser. The pure water is collected in a measuring jar Experiments were toted on one slope solar unit during the period of March 2019 to April 2019. Experiments were toted between 9 A.M and 5 P.M. K-type thermocouples were fixed to various components of the still to measure the temperature. Temperatures were measured for basin liner, water, vapor, inner glass surface temperature, outer glass temperature and ambient temperature. Incident solar radiation is the key factor that affects the distillate produce of the unit. To maximize the distillate produce, still has to be sealed perfectly and insulated to curtail the heat losses to environment.A trapezoidal unit with pool area of 0.7*0.7 m^2 is fabricated with 17° inclination for the condensing surface. To receive the utmost irradiance throughout the day the still is faced due south. A parabolic concentrator of one meter diameter is used to reflect the incident solar radiation on to a spherical absorber of diameter 0.65 m. The inlet and outlet of the absorber are connected to the inlet and outlet of the still with the help of transparent tubes. Volume of water in the still is 24.5 liters and volume of water in the absorber is 4 liters. Due to change in water hotness in the unit and the absorber Thermosyphon effect is produced and the water circulates naturally between them resulting in increased water temperature in the still and high distillate output. Water in the still gets evaporated quickly due to the Thermosyphon effect.Experiments were toted on one slope solar unit and the same attached to the parabolic concentrator. It is found that the optimum depth for one slope unit is 4 cm and for the still attached to parabolic concentrator is 5 cm.

Table.1: Experimental observations of solar still with parabolic concentrator

Sr.No	Time T in Hrs.	Temperature T in [° c]						I-[W/m^2]
		Ta	Tgo	Tgi	Tv	Tw	Tb	
1	9.00	32	32	39	34	32	32	130
2	10.00	35	36	44	40	34	34	300
3	11.00	36	40	49	48	46	47	421
4	12.00	36	48	56	58	58	58	647
5	13.00	35	56	62	67	66	67	785
6	14.00	39	61	65	70	70	70	909
7	15.00	40	62	66	72	72	71	925
8	16.00	39	59	62	67	67	67	876
9	17.00	36	53	55	59	62	61	766

Fig.1: Pictorial view of still with parabolic concentrator.

III. RESULTS

In this research, experiments are conducted on a single slope solar still attached with parabolic concentrator with basin area of 0.7 m ×0.7 m. Figure shows the experimental observations of one slope unit with concentrator.

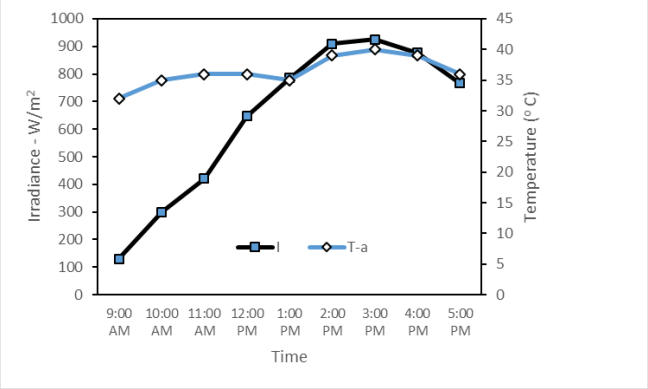

Fig.2: Observations of ambient temperature and irradiation

From Fig.2, it is observed that ambient temperature as well as irradiation increases with time.

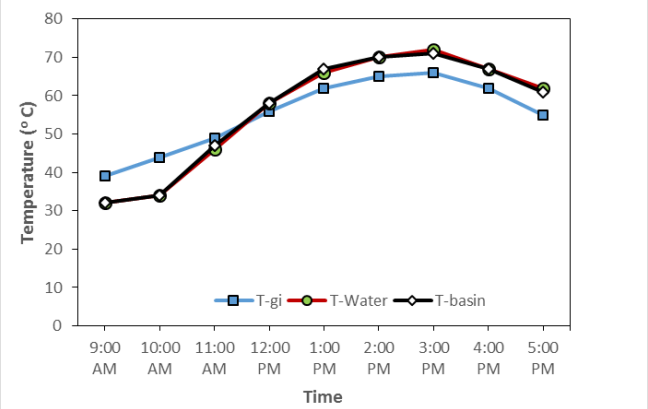

Fig.3: Hourly temperature variation for inside glass surface, water and basin.

Fig.3 Due to increase of temperature variance between condenser inside surface and water the rate of evaporation also increases.

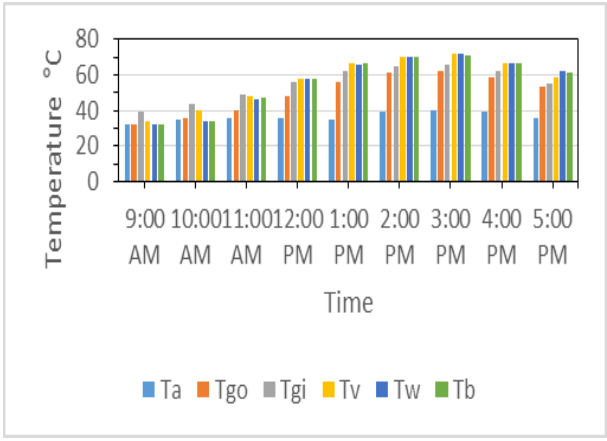

Fig.4: Hourly variation of Still Components

From the Fig.4, we can observe that there is an increase in the temperatures of still omponents with time. At 3 PM all components had highest temperatures.

The experimental setup was designed and installed in the city of Vijayawada. Experiments were initiated from 9 A.M to 5 P.M under the simulated conditions and the temperatures were recorded for basin liner, water, vapor, inner glass surface, outer glass surface and the ambient for everyone hour. Hotness is calibrated with the assistance of k-type thermocouples and registered in data logger. The hourly irradiance was provided by the weather center in K.L.University for all the days of experiment. As the hotness variation for water and condenser inside surface increases the evaporation rate of water in the basin increases.

Dunkle's relations are used in evaluating evaporative heat transfer coefficient which in turn is used to calculate hourly yield.

IV. CONCLUSION

An attempt is made in this work for providing pure water by using one slope solar unit. In this model the effect of water level on the yield is considered. As the area of the basin is small the yield produced increased with increase in the water level in the basin. The optimum depth for one slope unit is 4 cm and to the still attached to the concentrator is 5 cm. Results predict that the distillate produce is more for the still conjoin with parabolic concentrator when compared to the one slope solar unit. Distillate produced for the unit without attachment of concentrator is 4.2 L/m^2 /day and 5.7 L/m^2/day for the unit conjoin to the concentrator. The distillate output is increased by 35.7 % when the still is coupled to the parabolic concentrator.

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