A Review to Increase Productive Output of An Active Solar Distillation System

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***Abstract*—**Solar still is one of the best solutions to solve water problem in remote arid areas. One of the methods to increase the productivity is by decrease the volumetric heat capacity of the basin. Solar distillation is one of many processes that can be used for water purification. Solar radiation can be the source of heat energy where brackish or sea water is evaporated and is then condensed as pure water. So many works can be done on the active and passive solar still. From this review found that if we make the still double basin and two stages the overall efficiency of the active solar still will increase.

***Keywords*:** *solar still, solar collector, inverted absorber, PV/T collector.*

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I. INTRODUCTION

Different types of treatment processes are available to supply clean drinking water, to rural and urban areas in large and small scales. But, for the peoples living in remote arid areas, no device is available at affordable cost, to supply potable water. Use of different types of renewable energies for desalination has been comprehensively reviewed by Kalogirou [1]. Solar still is one of the best desalination devices. The still uses solar energy for converting available brackish or impure water into clean potable water. It is easy to fabricate and require no maintenance [2]. But the still is not popularly used because of its lower production. A number of works was carried out by researchers, to improve the production capacity of the still, by adopting different techniques [3]. Solar energy is available in abundant in most of the rural areas and hence solar distillation is the best solution for rural areas and has many advantages of using freely available solar energy. It is a simple technology and more economical than the other available methods. A solar still operates similar to the natural hydrologic cycle of evaporation and condensation. The basin of the solar still is filled with impure water and the sun rays are passed through the glass cover to heat the water in the basin and the water gets evaporated. As the water inside the solar still evaporates, it leaves all contaminates and microbes in the basin. The purified water vapour condenses on the inner side of the glass, runs through the lower side of the still and then gets collected in a closed container [4]. Many solar distillation systems were developed over the years using the above principle for water purification in many parts of the world. This paper reviews the technological developments of various active solar distillation systems developed by various researchers in detail. The review also extends to thermal modeling of some active solar distillation systems, comparative studies of different active solar stills, scope for further research and recommendation.

II. DESIGN OF SOLAR STILL

Solar still is an airtight basin, usually constructed out of concrete/cement, galvanized iron sheet (GI) or fiber/glass reinforced plastic (FRP/GRP) with a top cover of transparent material like glass, plastic etc. Inner surface of the solar still is blackened coating of absorber material to absorb solar radiation more effectively. Slope is provided for receive maximum solar radiation during the day period to the transparent glass cover which have negligible thermal conductivity. [5]

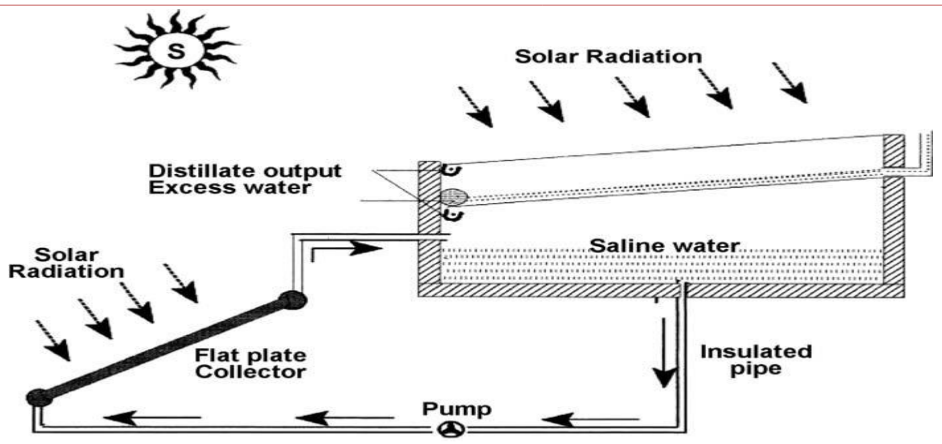

Figure 1. Active Solar Still [5]

This allows maximum solar radiation in the inner surface and distilled water collected at the end of glass cover and received by bucket. Temperature difference between evaporating water surface and condensing glass surfaces are increased by adding additional heat using solar collector, hot water tank, heat exchanger arrangement outside the solar still which is called active solar still as shown in Figure 1.

III. Improvement in Active Solar Distillation System

Our main focus is to improve the efficiency of active solar still. The numerous parameters are affecting the performance of the still such as material of the basin, wind velocity, water depth in the basin, solar radiation, ambient temperature, inclination angle and type of collector used. The productivity of any type of solar still is determined by temperature difference between inner surface of glass cover and surface of water.

Sanjeev kumar et al. Present an Annual performance of an active solar still. The following assumptions have been made while writing the energy balance for each Component:

- The heat capacity of the glass cover and the Insulation (bottom and sides of the still) is Negligible
- The solar still is vapour-leakage proof
- Side area of the still is very small as compared to area of basin liner due to a small depth of Water in the basin.
- No stratification of water occurs in the basin of the solar still
- Absorptive of the glass cover is negligible

By this experiment they can derive an analytical expression for water; glass cover temperature and yield have been derived in terms of design and climatic parameters.

- Glass cover

$$\alpha_g I(t) A_g + h_{1w}\left(T_w - T_g\right) A_w = h_g\left(T_g - T_a\right) A_g \quad \ldots(1)$$

- Water mass

$$\dot{Q}_U + \alpha_w\left(1-\alpha_g\right) A_w I(t) + h_w\left(T_g - T_w\right) A_b = \left(m_w C_w\right)\frac{dT_w}{dt} + h_{1w}\left(T_w - T_g\right) A_g \quad \ldots(2)$$

- Basin liner

$$\alpha_b\left(1-\alpha_g\right)\left(1-\alpha_w\right) A_b I(t) = \left[h_w\left(T_b - T_w\right) + h_b\left(T_b - T_a\right)\right] A_b \quad \ldots(3)$$

And hourly yield per unit area can be evaluated from known values of water and glass temperatures, and it is given by,

$$\dot{m}_{ew} = \frac{h_{ew}(T_w - T_g)\times 3600}{L} \quad \ldots(4)$$

From this experiment they conclude that for maximum annual yield, the optimum collector inclination for a fiat plate collector is 20 ° and for the still glass cover it is 15° [6].

G.N. Tiwari at al. work with the number of PV/T collectors connected in series has been integrated with the basin of solar still. The optimization of number of collectors for different heat capacity of water has been carried out on the basis of energy and exergy. Expressions of inner glass, outer glass and water temperature have been derived for the hybrid active solar system. For the numerical computations data of a summer day for Delhi climatic condition have been used. It has been observed that with increase of the mass of water in the basin increases the optimum number of collector. However the daily and exergy efficiency decreases linearly and nonlinearly with increase of water mass. It has been observed that the maximum yield occurs at N = 4 for 50 kg of water mass on the basis of exergy efficiency. The thermal model has also been experimentally validated. [7]

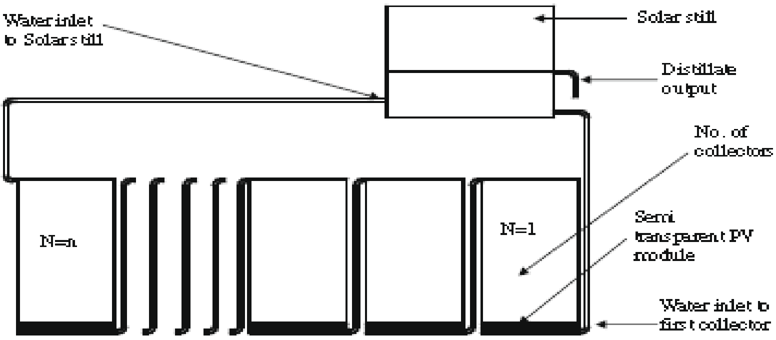

Figure 2. Schematic diagram of PV/T collectors connected in series [7]

Vimal Dimri, Bikash Sarkar, Usha Singh, G.N. Tiwari evaluate inner and outer glass temperature and its effects on yield. Numerical computations have been performed for a typical day in the month of December, 2005, for the climatic condition of New Delhi. Higher yield was observed for an active solar distillation system as compared to the passive mode due to higher operating temperature differences between water and inner glass cover. The parametric study has also been performed to find out the effects of various parameters, namely thickness of condensing cover, collector absorbing surface, and wind velocity and water depth of the still. It is observed that there is significant effect on daily yield due to change in the values of collector absorbing surface, wind velocity and water depth. For all the cases, the correlation of coefficients (*r*) between predicted and experimental values have been verified and they showed fair agreement with $0.90 < r < 0.99$ and root mean square percent deviation $3.22\% < e < 22.64\%$. Effect of condensing cover materials, namely copper and polyvinyl chloride (PVC), on daily yield have also been investigated and compared. [8]

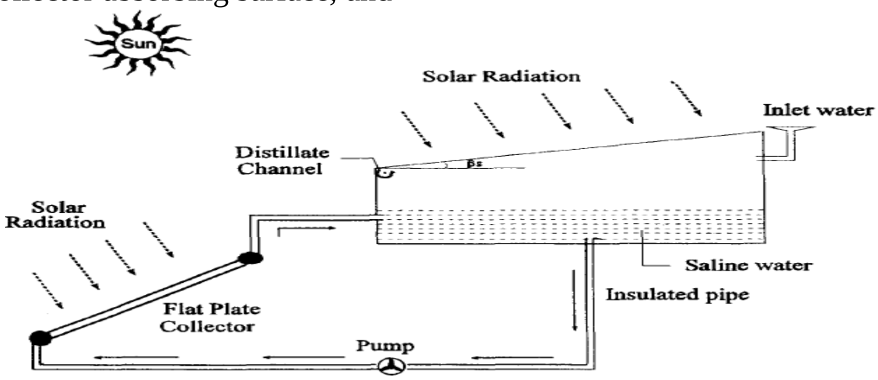

Figure 3. Schematic view of an active solar still coupled with a flat plate [8]

Rajesh Tripathi, G.N. Tiwari Presents the thermal analysis of passive and active solar distillation system by using the concept of solar fraction inside the solar still with the help of AUTOCAD

2000 for given solar azimuth and altitude angle and latitude, longitude of the place. Experiments have been conducted for 24 h for New Delhi during the months of November and December for different water depths in the basin (0.05, 0.1 and 0.15 m) for passive as well as active solar distillation system. [9]

Figure 4. Photograph of the experimental set-up [9]

Analytical expressions for water and glass cover temperatures and yield have been derived in terms of design and climatic parameters. It is observed that;

(i) The solar fraction plays a very important role at lower values of solar altitude angle

(ii) The internal convective heat transfer coefficient decreases with the increase of water depth in the basin due to decrease in water temperature,

(iii) There is a fair agreement between the experimental observation and theoretical prediction during daytime as compared to that during the night.

Hiroshi Tanaka, Yasuhito Nakatake and Masahito Tanaka work on some indoor experiment in vertical multi effect diffusion type solar still. They coupled a heat pipe solar collector with solar still and lamps are used instead of solar radiation.

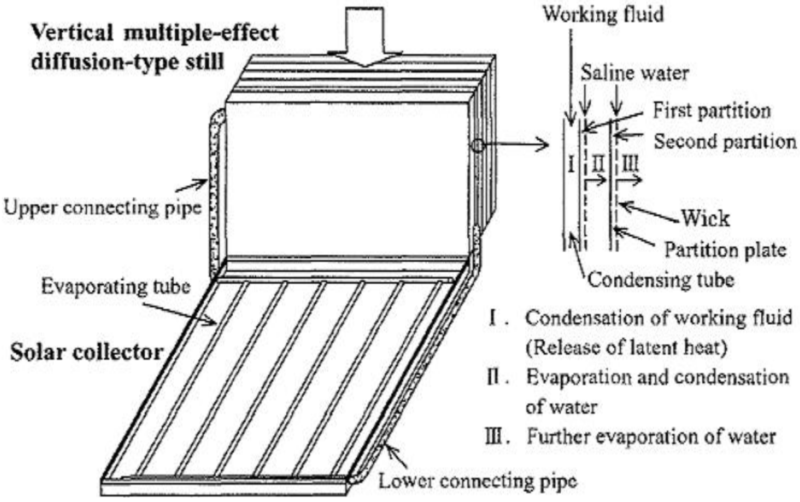

Figure 5. Schematic diagram of vertical multiple-effect diffusion-type still coupled with a heat- pipe solar Collector [10]

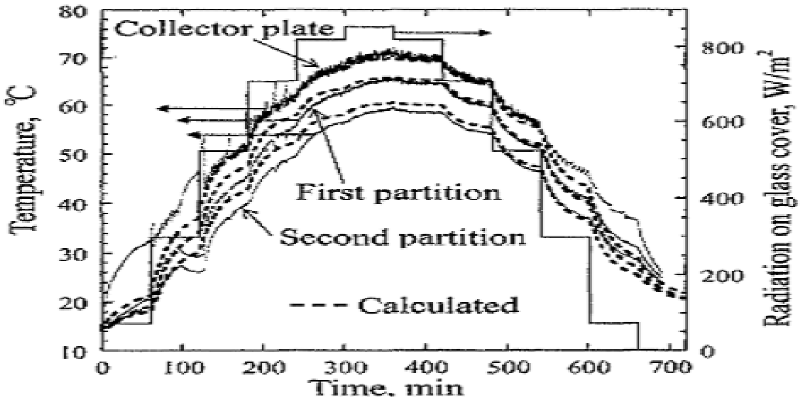

Figure 6. A Graph of Temp – Time - solar radiation [10]

Size of this still is very compact, and the thickness is less than or equal to 10 cm, when it is carried or in storage, furthermore, the proposed still was predicted to produce a greater amount of distilled water than that of a conventional multiple effect diffusion type solar still without electricity.

The predicted time variation of temperatures of the collector plate of the solar collector and the experimental results, and the experimental results of the experimental results of the overall production rates of the multiple-effect still were about 93% of what was predicted. This indicates that the heat pipe of the proposed still can transport thermal energy well from the solar collector to the vertical multiple-effect diffusion-type still. Result as shown in fig.6. Time variations of the temperatures in the still and the distillate production rate on the second partition produced by varying the radiation from the heating lamps to imitate actual solar radiation are in good agreement with the predictions. [10]

Sangeeta Suneja, G.N. Tiwari works on transient analysis of a double basin solar still. They derived explicit expressions for the temperatures of various components of the inverted absorber double basin solar still and its efficiency.

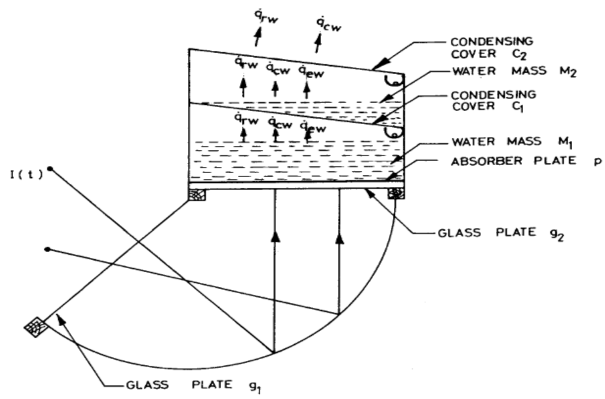

Figure 3. Schematic view of an inverted absorber double basin solar still [11]

The effect of water depth in the lower basin on the performance of the system has been investigated comprehensively. For enunciation of the analytical results, numerical calculations have been made using meteorological parameters for a typical winter day in Delhi. It has been observed that the daily yield of an inverted absorber double basin solar still increases with the increase of water depth in the lower basin for a given water mass in the upper basin. [11]

IV. FUTURE SCOPE AND CONCLUSION

- From above review conclude that productivity of active solar still will increase with increasing solar collector area. There is lots of work done to improve the solar still and they generally used flat plate collector, inverted absorber. But if make them double stage and with the use of highly effective collector they work as a one unit system and overall efficiency of the system is increasing. So, the productive output of still almost doubled

- The natural circulation mode (Thermo-siphon Effect) is to be used in active solar still to avoid electricity consumption by pump in forced circulation mode.
- More research may be carried out in active solar stills with other developed technologies like ETC, ETC with heat pipes and multistage solar distillation.

V. SYMBOLS

A Area

c_w Specific heat of water in the solar still, j / kg °C

h_{1g} Convective heat transfer coefficient from the basin liner to an ambient air through bottom and side insulation, W/m2°C

h_{1w} Total heat transfer coefficient from the water surface to the glass cover, W/"#°$

h_w Convective heat transfer coefficient from the basin liner to the water, W/m2 °C

h_{ew} Evaporative heat transfer coefficient from the water surface to the glass cover, W/m2 °C

I(t) Solar Radiation available at the plane of glass cover of the solar still, W/m2

$\dot{m}_{ew}$ Instantaneous yield of still per unit area, kg/ m2

$\dot{Q}_U$ Rate of useful energy from collector, W

T_a Ambient Temperature

Subscripts

g glass cover

w water

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