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A Review on Performance and Heat Transfer Enhancement in Solar Still

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ABSTRACT

The earth's surface covers 71% of water area. Drinking water is a necessary thing for all living organism in the earth. But the availability of potable water is no longer available in rapid increase of population. So one of the way to obtain clean water from saline water is solar desalination. Solar desalination is the process of obtaining clean water from saline water. For desalination a device solar still can be employed. The solar still is one of the effective ways of desalinating saline water with an affordable price. Using extended surface the productivity of solar still is increased. The extended surface is modified to improve the evaporation rate and to absorb more solar radiation. Present review paper shows the use of extended surface in solar still and how to increase solar still production.

Keywords: Solar Desalination, Extended Surface, Solar Still, Evaporation Rate, Reflectors, Solar Pond.

I. INTRODUCTION

One of the primary requirements for the survival of all living organisms on earth is fresh water consumption. While 71% of the earth's surface is covered by water, The saltwater holds 97% and freshwater holds 3%, which is very less compared to total water and the percentage of directly drinking water is only 0.36% in total water [1-2]. The value for the drinking water is 1.5 ppm. The fluoride present in some places are much higher than the recommended value of World Health Organization (WHO). The value of salt concentration in potable water should not be more than 500ppm. But in naturally available saline water this value is much higher. To overcome this issue solar desalination method is used to obtain fresh drinking water from saline water. From various desalination method solar still is one of the effective ways to obtain fresh drinking water at an affordable price. But the solar still has major problem of getting lower efficiency and less productivity [3-5]. In solar still the components consist of glass cover, basin, absorber plate, insulation, distillate trough etc. The solar still has lower distillate output, hence it is required to increase by using extended surfaces in the solar still. The need of distillation is to purify water from virtually any source, including oceans, to provide clean drinking water without need for an any external source and easy to use interface [4]. It describes about how solar rays can be energized using solar still to carry out desalination process and to produce drinking water from saline water.

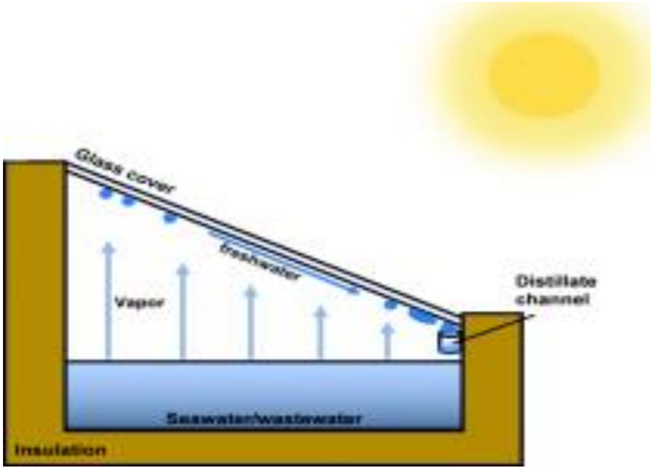

Figure 1. Solar still [1]

II. WORKING PRINCIPLE OF SOLAR STILL

The process of heat transfer in solar still are classified into two different types internal heat transfer and external heat transfer. The solar still absorbs thermal energy from sunlight to distillate saline water into fresh drinking water. It distillate saline water by using the heat of the sun to evaporate water. The solar radiation from the sun passes through the glass cover, falls on the water surface in the basin plate and gets absorbed. To increase the productivity of solar still, extended surface to is used below the basin plate[4]. Due to absorbing of solar radiation from sun, water gets heated and start to evaporates and rises upward to touches the inner surfaces of the glass cover and from tiny water droplets. The glass is fixed at an inclined angle with the outer body. The tiny water droplets moves down at lowest edge of the glass cover and the water can be collected through outlet pipe. In solar still there is no external power source for heat transfer [6].

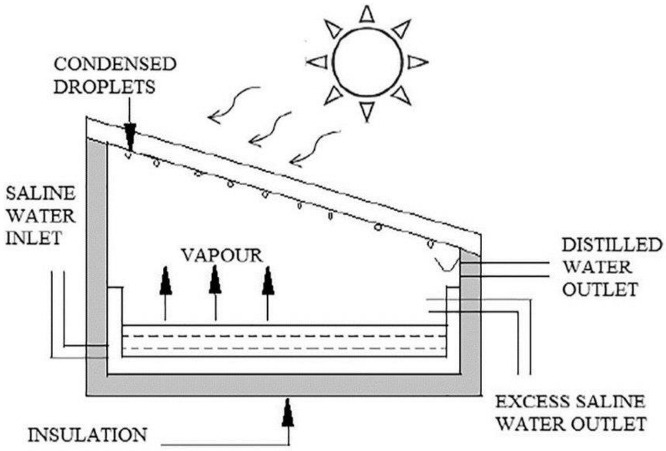

Figure 2. Working principle of solar still

III. IMPACT ON ENHANCEMENT IN SOLAR STILL USING EXTENDED SURFACES FOR THE HEAT TRANSFER

Table 1 presents the results of enhancement in solar still using extended surfaces for the heat transfer.

Table 1 : Effect on extended surfaces for the heat transfer

Author Name	Modifications incorporated	Results
Velmurugan et al. [7]	Solar stills integrated with a mini solar pond	57.8% productivity enhanced.
Shukla et al. [8]	Incorporated with a wet piece of jute cloth in both single and double slope solar stills.	1.3 times more than single slope multi-wick.
Kabeel [9]	Incorporated with a black concave jute wick surface.	99% of the minerals is removed during distillation.

Tanaka et.al [10]	Solar still installed with internal and external reflectors.	48% productivity enhanced.

3.1 SOLAR STILLS INTEGRATED WITH A MINI SOLAR POND

Velmurugan et al. [7] designed a mini solar pond supported solar still is presented with comparison of theoretical and experimental analysis. The saline water presented in the mini solar pond is 80 g/kg of water. The productivity of solar still is found to be increased, when it is supported with the mini solar pond. A solar still has an area of 1m^2 with 10degree inclination [7]. In the mini solar pond there are three zones being maintained. They are UCZ, NCZ and LCZ [11]. In upper convective zone saline water is much less compared with fresh water [12]. In non-convective zone saline water increases with the depth. In lower convective zone it increases the temperature with solar radiation [13].

The mini solar pond is closed with the plywood. The size of the box is for evaporation area is 1m*1m. It is filled with sawdust for insulation purpose. The depth of the saline water for the experimentation is 2cm. The inner surface is coated with black paint which absorbs more solar radiation to increase productivity. The mini solar still is connected through a flow control valve. The readings are taken for every 30 minutes. The productivity of mini solar pond is supported with sponged still is 57.8% [7]. In upper convective zone saline water is much less compared with fresh water.

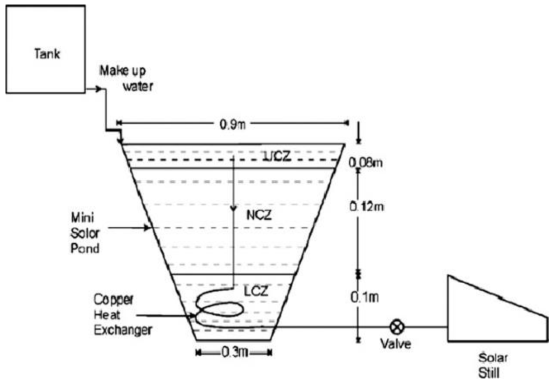

Figure 3. Experimental setup of mini solar pond [7]

3.2 THERMAL MODELING OF SOLAR STILLS

Shukla et al. [8] designed using both single and double slope solar still incorporated with wet piece of jute cloth. The experimentation is carried out with multiwick single slope solar still and multiwick double slope solar still. In single slope solar still it has an evaporation area of 1m*1m and enclosed with fibre reinforced plastic. The glass is fixed with 10degree inclination in vertical direction of the solar still. The solar still was placed 1m from the ground. One end of the wet jute piece is dipped in the basin plate. Whereas in the double slope solar still one end is dipped in the water reservoir and other end is dipped in the absorber plate. The black paint coated on the absorber plate. When the results is compared the multiwick double slope solar still has 1.3 times more than single slope multi-wick [8].

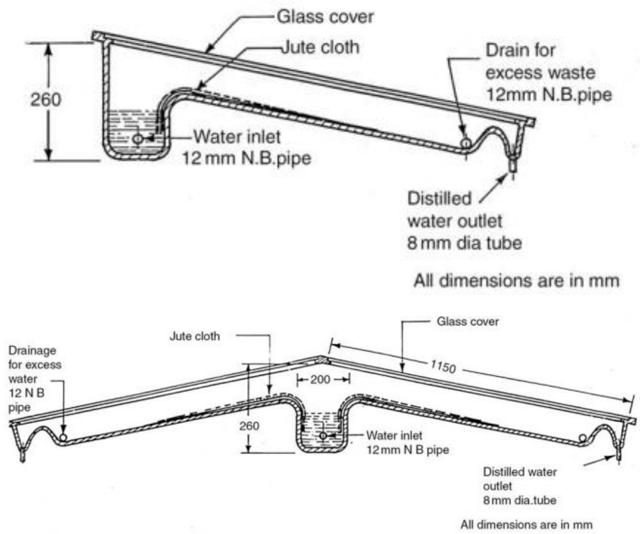

Figure 4. Multiwick single and double slope solar still [8]

3.3 PERFORMANCE OF SOLAR STILL WITH A CONCAVE WICK EVAPORATION SURFACE

Kabeel [9] designed for evaporation concave wick surface was used. For condensation four sides of a pyramid shaped still used. The basin plate contains a evaporation area of 1.2m*1.2m. The ordinary window glass with 3mm thickness is used for glass cover on four sides of the solar still with an inclination of 45 degree placed with horizontal surface [14]. During experimentation the productivity of the proposed still during the 24 h time is about 4.01/m². The proposed solar still with a concave efficiency reached about 45% [9].

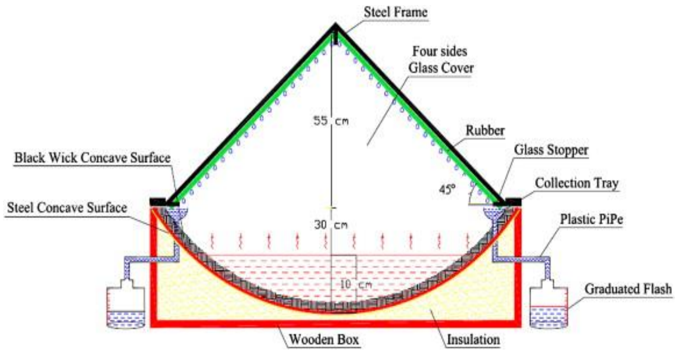

Figure 4. Schematic diagram of concave wick solar still [9]

3.4 BASIN TYPE SOLAR STILL WITH INTERNAL AND EXTERNAL REFLECTORS

Tanaka et.al [10] designed basin type still is designed with internal and external reflectors. The reflectors are used to increase the productivity throughout the year. The solar still is placed with the 30degree latitude. It gives the average result of 48% throughout the year.

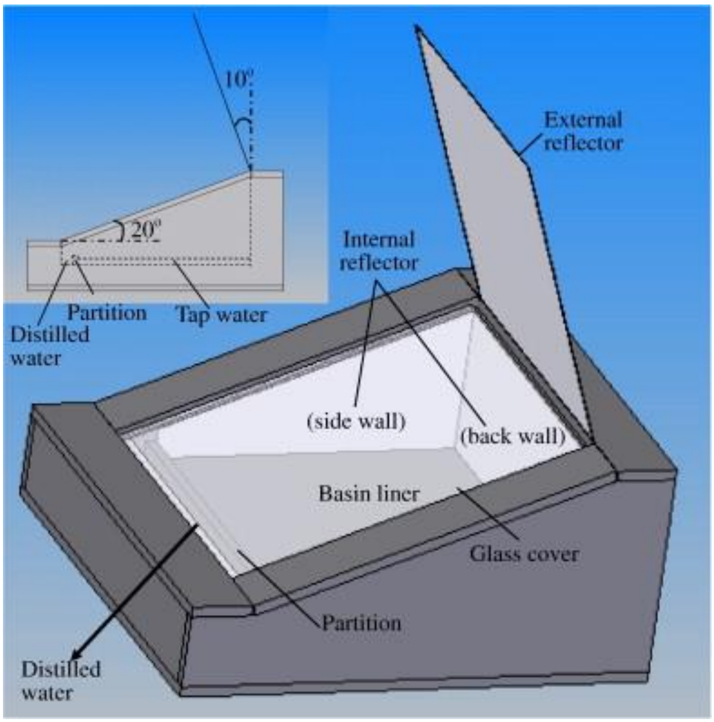

Figure 5. Basin type solar still with internal and external reflectors

IV.CONCLUSION

The least expensive method to produce water is by solar desalination process. Phase change material (PCM), black paint coating, black paint blended with nanoparticles coating, wick materials, nanoparticles with PCM, modifications to absorber, attachment of external surfaces which improves the production of fresh water and increases the efficiency of the solar still, are some of the research methods used for this process [25-30]. From this study, the following conclusions are made:

- By using wick material, the evaporation rate is enhanced and thus it is used to improve the production rate.
- Nanoparticles blended with black paint coating over the absorber plate increase the absorption rate and thus increase the solar still efficiency.
- Paraffin wax as PCM and PCM combined with nanoparticles considerably boost the maximum

productivity of the solar still by raising thermal conductivity.

- Nanoparticles are used in solar stills because they increase thermal conductivity, absorption rate, daily efficiency, and freshwater yield [31-33].

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