A Review on Factors Affecting the Performance of A Single Basin Solar Still

Ajay Singhal, Manoj Kumar Sain, Ankit Agarwal
Department of Mechanical Engineering
Swami Keshvanand Institute of Technology Management & Gramothan, Jaipur
Email- ajjayagrwal@gmail.com, mksain1435@gmail.com, akagarwal.87@gmail.com
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Abstract: **Pure water requirement for the living of human on earth has been increased with the increase in the population. Most of the water available on the earth is brackish or impure which cannot be used in its present form. The solar distillation is the best technology to resolve this problem, but the low productivity of the solar still is the biggest challenge. In this review paper, several factors are discussed which enhance the productivity of solar still. From the literature, optimum water depth is found 1 cm to 2 cm, optimum glass tilt angle is found approximately equal to the latitude of that place and optimum insulation thickness for thermocol is found as 25 mm.**

Key Words: **solar still, glass cover, single slope, productivity, nanoparticle, absorber surface.**

1. INTRODUCTION

Nearly 1.1 billion individuals in this world have lacking access to safe drinking water. There are 26 nations do not have enough water to keep up agriculture and financial advancements. Rivers, lakes and groundwater reservoirs for fresh water requirement are going to be depleted. Most of the diseases are due to brackish water [1]. According to a survey, 79% of the water available on the surface of earth is salty and in the form of sea water. 20% of the water available is brackish and only one percent of water is available as the fresh and drinkable water [2]. Distillation is a technique to convert brackish or impure water into fresh and drinkable water. Some of the conventional distillation processes such as Multi-effect evaporation, thin film distillation, Multi-stage flash evaporation, reverse osmosis and electrolysis are the most feasible solution for large water requirements [3]. Solar still is an easy technique for distilling water which utilizes the low cost available solar energy. It is widely used to produce potable water [3][4].

1.1 Objective of paper

The aim of this paper here is to reveal the various past works over enhancement in productivity of a single slope single basin solar still. In this paper, most of the parameters affecting the performance of solar still are discussed with their results for future work.

1.2 Factors affecting performance of a solar still

performance of solar still can be enhanced by optimizing some affecting factors. By literature following factors affect the performance of solar still

- Depth of water
- Glass cover tilt angle
- Coating on absorber plate
- Material used for insulation
- Design of still parts structure
- External enhancements

2. LITERATURE REVIEW OF RECENT TRENDS TO INCREASE PRODUCTIVITY

2.1 Effect of water depth

In the study by Akash et al. [5], it was found that the maximum yield was for the least water depth [4]. Maintaining minimum depth of water in the solar still may appear dry spots. So, it is very difficult to keep the minimum depth of water in solar still. Therefore, some methods have must be invented to maintain optimum depth of water. Phadatre and Verma [6] analyzed the influence of water depth on internal heat and mass transfer in a plastic solar still of Plexiglas. An operational parameter of water depth was kept from 2 cm to 12 cm. It was found from the experiment that as depth of basin water increased the output decreased.

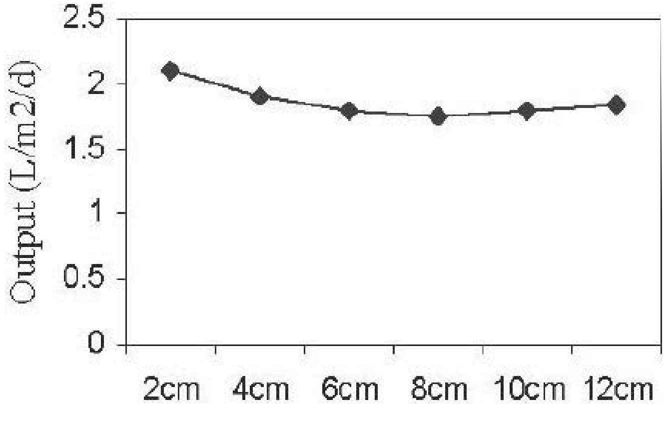

Figure1: Variation of distillate output with water depth [6]

The basin water temperature was found inversely proportional to the basin water depth. In the experiment the convective heat transfer coefficient was reported less than the radiative heat transfer coefficient and evaporative heat transfer coefficient was highest at that point. From figure1 it can be seen that the maximum output of the still is at 2cm water depth [6].

The efficiency of solar still for different water depth is shown in figure 2.

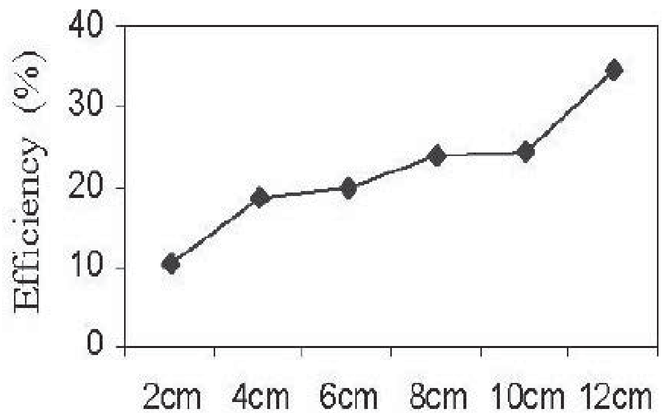

Figure2: Variation of efficiency with water depth [6]

Singh and Tiwari [7] analyzed active and passive solar stills at various climate conditions and the effect of water depth on productivity was seen. It was found that the optimum water depth varied with the climate conditions. Figure3 shows the monthly output of still at different water depth.

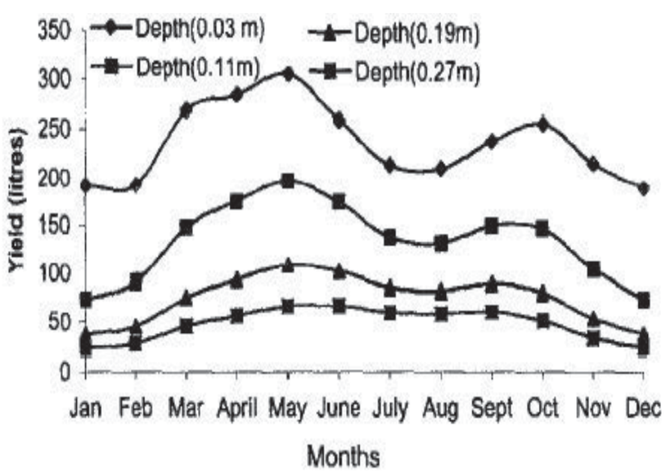

Figure3: Monthly output of an active solar still at different water depths [7]

2.2 Glass cover tilt angle

Glass cover plate plays an important role to receive solar radiation from the sun. Hence the tilt angle should be such that it can receive maximum solar radiation. It is observed that the glass cover tilt angle varies according to the location and for a particular location there is one optimumtilt angle which depends mainly upon latitude and elevation [8]. Distillate output increases with increase in temperature difference between evaporating surface and condensing surface and with increase in inclination angle [9].

2.3 Coating on absorber plate

2.3.1 Nanofluids

Elango et al. [10] used nanoparticles of Al_2O_3, ZnO and SnO_2 mixed with water in 0.05% and 0.1% concentrations to enhance the rate of heat transfer and rate of water evaporation, which improved the performance of the solar still. Production rate was maximum in case of Al_2O_3 water nanofluid which is about 29.95% higher and 12.67% and 18.63% higher production was there in case of ZnO and SnO_2 nanofluids respectively as compared to still with water at 0.1% concentration.

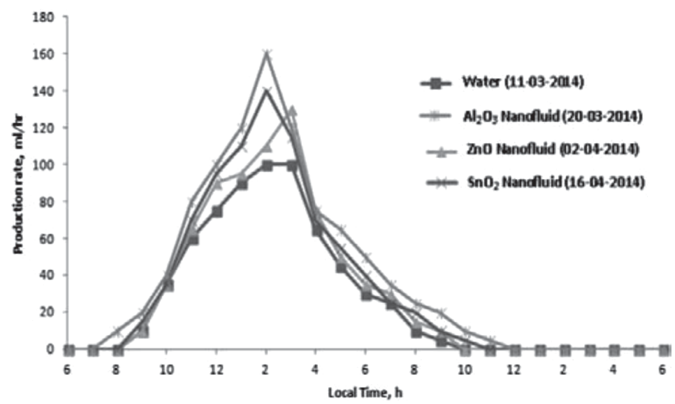

Figure4: Production rate variation with time [10]

2.3.2 Nanoparticles mixed with black paint

Sain and Kumawat [11] tested the performance of single slope single basin solar still using nanoparticles mixed with black paint on absorber. Study was conducted by using Al_2O_3 nanoparticles mixed with black paint to increase the radiation abruption of the absorber plate. The experiment was analyzed at water depth varying from 1 cm to 3 cm. Production achieved and efficiency of solar still using water depth of 1 cm was found 3.48 liter and 38.45% respectively. Increment found in production and in thermal efficiency using nanoparticles was 38.09% and 12.18% as compared to conventional still respectively. Results are shown in figure 5.

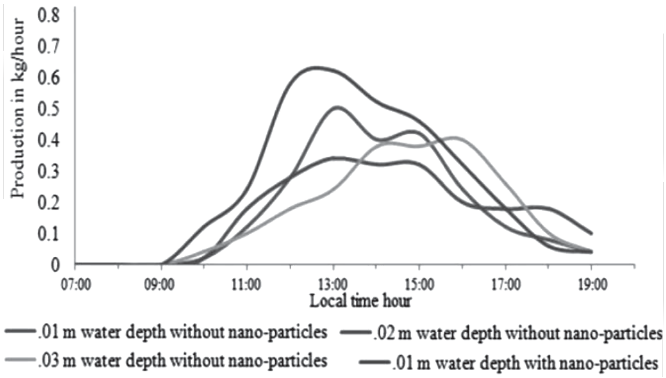

Figure5: Effect of nanoparticles on production rate [11]

2.3.3 Ink and black die in water solution

The effect of different absorbing materials on solar distillation was analyzed by Priya and Mahadi [12]. They used non-toughened glass glazing surface tilted at angle of 25° with water depth of 5 cm. Absorbing materials used were Ink and black dye in water solutions and the results were compared with the distillation without any absorbing material in the water tank. The experiment was carried out at 20 ppm, 30 ppm, 50 ppm and 70 ppm 3 concentration of black dye and Ink in feed water. It was observed that the distillation was improved with increase in concentration and the improvement was observed from 20 ppm to 50 ppm. Rate of evaporation was same when the concentration was increased from 50 ppm to 70 ppm.

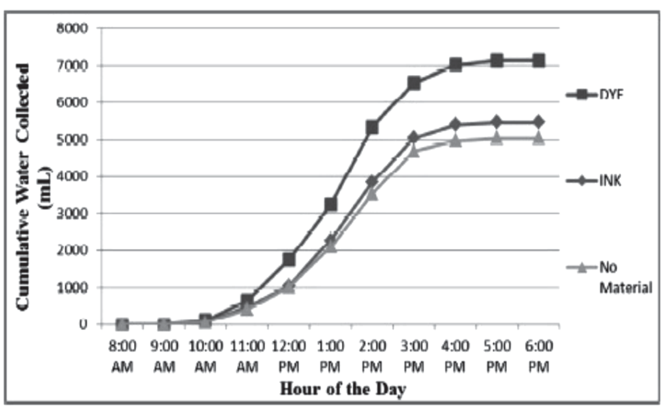

Figure6: Cumulative water collected hourly [12]

The black dye from the material showed the best results by an increase of nearly 65 per cent of water productivity, improved nearly 35 percent in the aqueous ink [12].

2.4 Materials used for insulation

Insulation is also an important part of still because these materials should have low conductivity and should be easily available [13].

Materials for basin and insulation in solar still prototype was evaluated by Burbano[14] they used Sawdust and Styrofoam which have low conductivity 0.09 and 0.037 respectively, and easily available, especially sawdust. Insulating thickness was kept 5 cm because a further increase in insulation thickness would result in rise the total yield. Increasing the thickness beyond 5cm has a little effect on the still production.

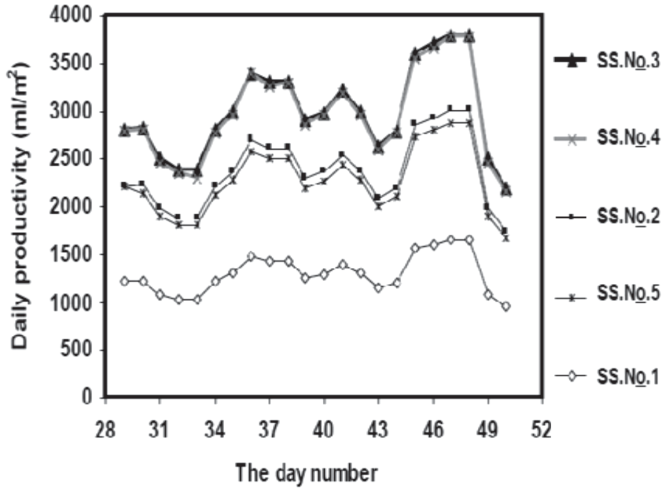

Figure7: Variation of productivity with days [15]

The performance of a solar still (SS) was compared by Hasim et al. [15] using five different materials as insulation. SS-1 was without insulation, SS-2 was with plywood, SS-3 was with glass wool and plywood, SS-4 was with 5 cm thickness of hay and plywood & SS-4 was with 5 cm thickness air gap between basin and the glass bottom. He found that SS-4 and SS-5.The variation of daily productivity with respect to time was found as shown in figure 7.

2.5 Design of still parts

While maintaining the minimum depth in the solar still dry spot formation occurs. Therefore, for maintaining the minimum depth in the solar still, absorber plate having a stepped structure formed by Velmurugan (2008) [16]. Fifty trays of dimension 99 × 99 mm2 were used in this experiment. Use of fins and sponge ladder were also used in this experiment on singe slope solar still which increased its productivity as shown in figure 8.

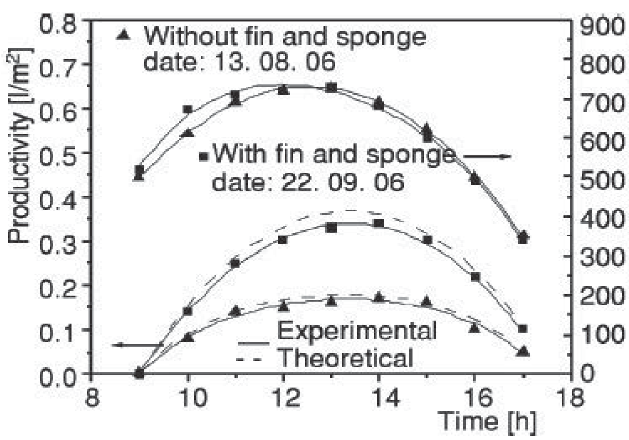

Figure8: Productivity enhancement of stepped solar still [16]

Arun Kumar et al. [17] used seven solar still designs such as spherical solar still, hemispherical solar still, pyramid solar still, double basin glass solar still, concentrator coupled single slope solar still, tubular solar still and tubular solar still coupled with pyramid solar still. All the solar stills were operated on the same climatic conditions in order to analyze the impact on productivity enhancement. Figure 9 shows the comparative view of production yield of these seven solar still designs. Compound parabolic concentrator solar assisted still showed the highest yield.

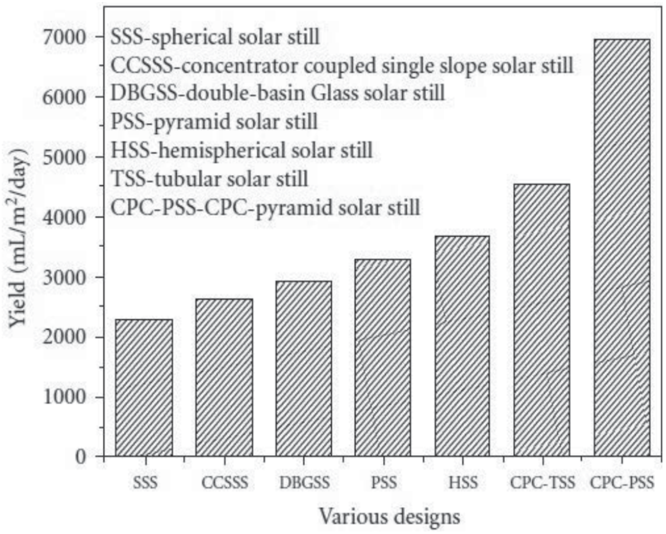

Figure9: Variation of yield according to design [17]

The performances of the single basin solar still made up of Copper and GI was compared by Gnanadason [18]. In 4 the study wood was used as an outer box and was covered with the thermocol of 25 mm thickness. Using copper as still basin material, the evaporation rate and condensation rate was improved and the efficiency was also high as compared to GI. For the study, 0% and 20% concentration of salt was used in water of 1cm, 2cm, 3cm, 4cm, and 5cm depth. The basin was painted black to absorb maximum heat. The efficiency of copper sheet basin was increased by 80% when compared to GI sheet for same basin area which is shown in figure 10.

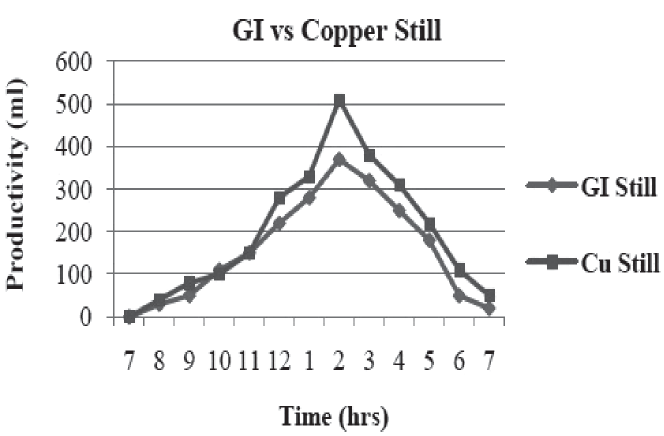

Figure10: Production rate variation of GI & copper still [18]

2.6 Effect of external attachments

2.6.1 Still with external condenser

The modified solar still integrated with external condenser using nanofluids was analyzed by Kabeel et al (2013) [19]. In the study 3mm glass cover was used at an inclination angle of 30o and 50mm thick fiber glass of low conductivity for insulation. The still used was made up of GI sheet of 1.5 mm thickness and painted black from inside surface to absorb maximum heat radiation. Nanofluid used was Aluminum Oxide (Al_2O_3). The condenser unit contains copper tube, brushless motor and vacuum fan. The experiment was conducted at water depth of 10cm at different fan speeds of 90, 450, 900 and 1350 rpm. The productivity is increased from the different fan speed 90, 450, 900 and 1350 rpm was approximately by 16.26 %, 21.65 %, 25.39 %, and 53.22 % respectively as compared to conventional still, figure 11 shows the same.

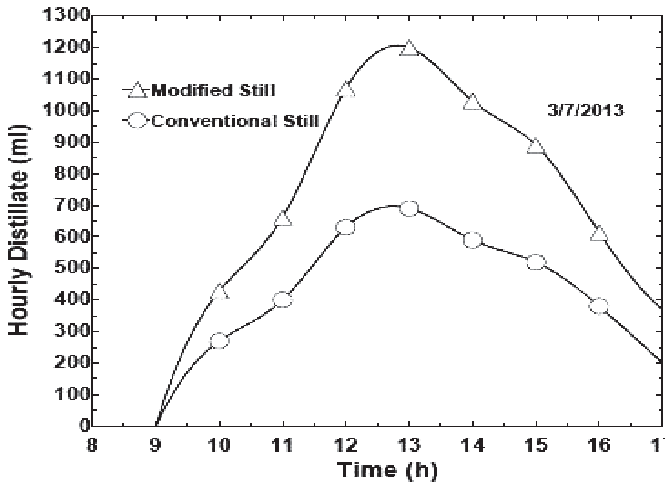

Figure11: Distillate output of modified and conventional still [19]

2.6.2 Still with vapor absorption basin

A solar still integrated with vapor adsorption bed at the basin was designed, manufactured and tested by Kannan et al. [20]. To improve the productivity of the still, sponge, sand, black gravels, black rubbers and some of their combinations were used. The output of the solar still was compared with the solar still without these materials. It was found from the experiment that distillate output in the vapor adsorption solar still was 3.1-4.3 kg/m^2 while the conventional still distillate output was 1.9 – 2.3 kg/m^2 [20]. The comparison of output is shown in figure 12.

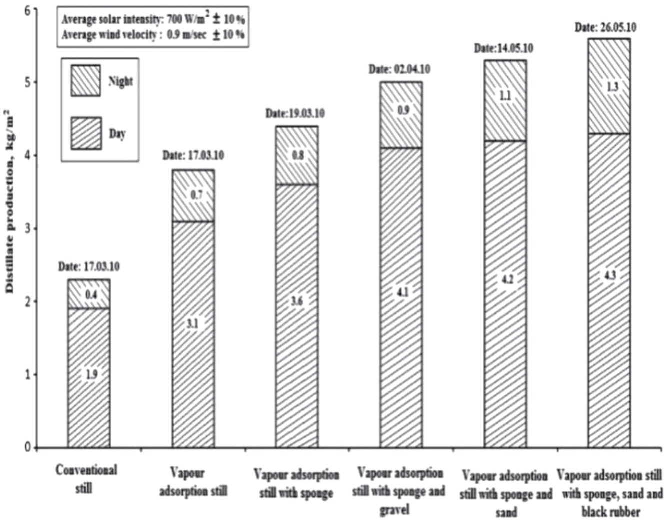

Figure12: comparison of distillate output of various combinations [20]

3. CONCLUSIONS

Based on the reviews made in this paper, following conclusions may be drawn:

- Maximum yield was achieved using the least water depth. Hence minimum water depth is preferred. Minimum, optimum water depth was 1cm.
- North latitude places south facing glass cover should be used and south latitude places north facing glass cover should be used.
- Lower thickness glass cover is preferred compared with higher thickness glass cover due to its higher absorptions and the optimum tilt angle was nearly equaled to the latitude of that place.
- Nanoparticles improved the productivity by enhancing the absorption rate of water. Using of suitable nanoparticles can reduce the overall cost.
- To improve the higher absorption of the water, black die was most preferable compared with another dies.
- The most suitable insulating material was found thermocol of 25mm thickness. Another preferred insulating material was glass wool, plywood.
- Using copper and GI basin the evaporation rate and condensation rate was improved.
- Rubber, gravel, saw dust and sponge cubes are good material to store the solar energy and increase the productivity of stilll.

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