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A Review to Increase the Performance of Solar Still: Make It Multi Layer Absorber

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Abstract- Water is the basic need to sustaining life on the earth for human. With the passage of time due to technical usage and their waste disposal along with ignorance of human being caused water pollution, which led the world towards water scarcity. To resolve this problem Solar Distillation is one of the best Techniques from available another techniques. But, due to its lower productivity it cannot be commercial in the market. So that Lots of work can be done to improve the solar still efficiency or productivity. With the help of past research work we can conclude that if we are using multi layer absorber type solar still than its productivity will going to be increased and reflective radiation losses are covered by this one.

Keywords: *solar still, passive, condensing glass cover, double slope, single slope*

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1. INTRODUCTION

Supply of drinking water is major problem in underdeveloped as well as in some developing countries. Along with food and air, water is a necessity for man. Man has been dependent on rivers, lakes and underground water reservoirs for fresh water. Most of the human dices are due to brackish water problem. Around 1.5 to 2 million children are die and 35 to 40 million people are affected by water borne dices. However the increasing industrial activities may lead to a situation where by countries need to reconsider their option with respect to the management of its water resources. Surveys show that the about 77 per cent of water available on earth is salty. Only one per cent is fresh and the rest of 20 per cent is brackish. Around 3% of the world water is potable and this amount is not evenly distributed on the earth. So, developed and under developed countries are suffering the problem of potable water. Distillation is an oldest technique to distillate brackish or salty water in to potable water. Various technologies were invented for desalination from time to time and it has been accepted by people without knowing future environmental consequences. Many developed countries have given utmost priority to rural water supply in their development plans. Distillation of brackish or saline water, wherever it is available, is a good method to obtain fresh water. However, the conventional distillation processes such as Multi-effect evaporation, Multi stage flash evaporation, thin film distillation, reverse osmosis and electrolysis are energy intensive techniques, and are the feasible for large stage water demands. The alternative solution of this problem is solar distillation system and a device which works on solar energy to distillate the water is called solar still. Solar still is very simple to construct, but due to its low productivity and efficiency it is not popularly used in the market. Solar still is working on solar light which is free of cost but it required more space. Its material is easily available in the market and it cannot require a higher skill for the maintenance. To increase the simple solar still efficiency so many works are done. Compared to passive solar still active solar still productivity is higher.

2. SOLAR DISTILLATION:

Solar distillation has been used for many years, usually for comparatively small plant outputs. Over the years, substantial research has been carried out to find out ways into improving the efficiency of the process. Research work has been carried out in many parts of the world. Solar distillation uses, in common with all distillation processes, the evaporation and condensation modes, but unlike other processes energy consumption is not a recurrent cost but is incorporated in the capital cost of the solar collector. The solar still therefore, is of a simple design, construction and maintenance with ease of operation. It is best suitable for regions of the world with high solar intensities.

The mechanism of operation is based on the transmitting, absorption and reflective properties of glass and other transparent materials. The glass has the property of transmitting incident short-wave solar radiation which

passes through the glass, the glass being a medium of transfer of heat, into the still to heat the brine. However, the re-radiated wavelengths from the heated water surface are infra-red and very little of it is transmitted back through the glass as it is shown in Figure 4. Today, producing volumes of pure potable water is not only technically feasible but equally economically viable using the desalination of seawater. The challenge though has been to produce potable water for rural communities for drinking and sanitation to help meet the Millennium Development Goal without compromising standards. In meeting the challenges of the provision of potable water for drinking and sanitation, huge desalination plants have been built. The introduction of dual-power plants were also deployed to reduce the cost of electricity and water which could impact negatively on the populace. [2]

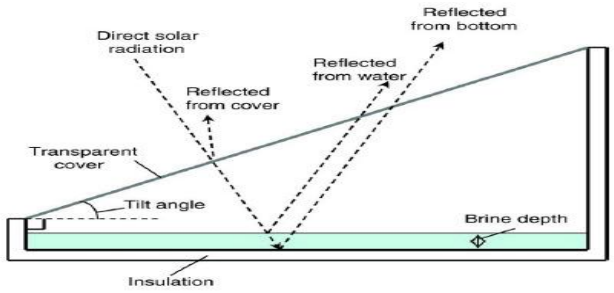

Figure 1: Schematic diagram of a basin-type solar still [1]

Exhaust heat from power plants were also deployed as an alternative for running desalination systems. These are large desalination systems though. However, not all water demands are coupled with the need for additional electric power. Solar energy may be deployed to produce fresh water from the sea. This may be accomplished in a large system or in a simple basin-type solar desalination unit. On a practical basis, certain things ought to be taken into consideration while designing and operating a solar still. For instance, shallow basins require large expanse of land. This land has to be cleared and leveled in readiness for the installation of the still; obviously this attracts some additional cost. Oftentimes and because the water to be treated is salt water, salt crystals build up on the dry part of the basins. This can reduce the overall absorption area of the basin, thereby impacting negatively on the effective basin area. Leakage can cause distillate to leak back into the basin or even leak out of the basin [3]. It is equally necessary to flush the still basin on a regular basis so as to remove accumulated salts and microbes that might have grown in the brines. The use of algaecides might also be encouraged to control the growth of algae.

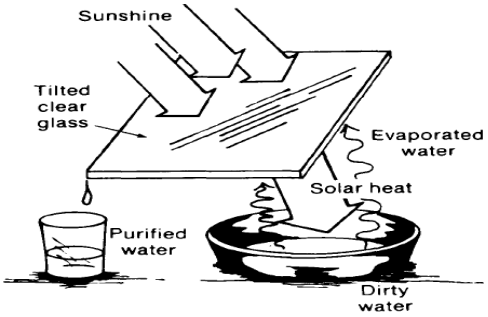

Figure 2: Basis concept of solar distillation [3]

3. SOLAR STILL:

The basin of the solar still is filled with brackish water and the sun rays are passed through the glass cover to heat the water in the blackened inner surface of basin and because of temperature difference between water and glass surfaces water gets evaporated. As the water inside the solar still evaporates, it leaves all contaminates and microbes in the basin. The purified water vapour will condensate on the inner side of the glass runs through the lower side of the still and then gets collected in a closed container which is used as drinkable water.

Many solar desalination systems were developed in years by using the above principle of solar still in the world. So many works done on solar still, on this work solar still is divided in two parts: (i) passive solar still, (ii) active solar still.

In a passive solar still, the solar radiation is received directly by the basin water and is the only source of energy to raise the water temperature and consequently, the evaporation leading to a lower productivity. This is the main drawback of a passive solar still.

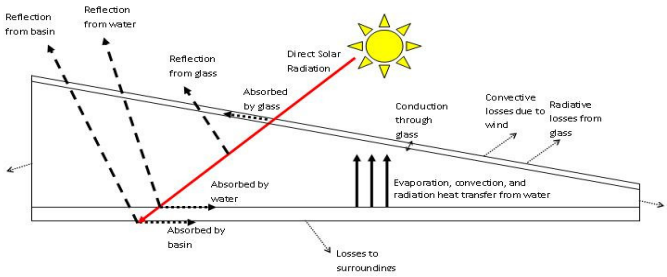

Figure 3 Simple solar still [4]

Later, in order to resolve the problem of lower productivity, many research work will go on or done on the conventional (passive) solar still and active solar still. This review extends to thermal modelling of some conventional solar distillation systems, comparative studies of different solar stills, scope for further research and recommendation.

4. IMPROVEMENTS IN PASSIVE SOLAR STILL

4.1 Improvements of Cover plate of Solar Still

The cover plate supports at the top of the solar still to receive the radiations of the sun and directed to the basin to evaporate the water. So if improvement is done in cover plate so due to incident of maximum radiation, productivity of solar still is increased.

4.1.1 Inclination and Direction of Cover Plate of Solar Still

For a given material of the cover glass, reflectance and transmittance are very important because lower the angle of incidence of sun rays, transmittance is higher and reflectance is lower hence evaporation of water inside the basin should be higher and productivity is increased. [5, 6] Latitude is also play an important role because helps to select the single basin and double slope solar still. In lower latitude places, double slope solar still and higher latitude places, single slope solar still is preferred. For solar still, cover inclination is also play important role because when the evaporation of water starts, water vapor is produced and due to its lower density it goes above and stick to the inner side of glass cover. So if inclination of cover is lower so water droplets will not reach to glass cover and fall inside the basin. Solar still with various angles like 10 to 50 degree have been tested. [7]. Tiwari et.al has taken experiment on solar still and found that there is a significant effect on performance of solar still. Angle of glass cover has also remarkable effect on performance. Optimum glass cover angle increase the condensation rate because slope is improved and speed of distilled water output is increased. Higher angle of slope reduces the condensation rate. [8]

4.1.2 Wind Velocity

Wind velocity has effect on productivity, but even low wind speeds increases the productivity of solar still compared with zero wind conditions. The fact is high wind speed or velocity increases the heat losses by convection from the cover to the ambient. This causes a decrease in the condensing surface temperature and accordingly increases the yield of a still. The experiment shows that when the wind speed or velocity changes from 1 to m/s decreases by 13%. [9]

4.1.3 Use of Sprinkler at Top of Solar Still

Sprinkler or cooling film is used to increase the condensation of the water vapor and increases the productivity. It is attached at top of the glass cover and it is perforated so from the perforated tray, water falls on the outer side of glass cover and cools it hence, the temperature of vapor decrease and it starts the condensed there. It works on principle "when temperature is decrease from its dew point temperature, it starts to condense". Number of experiments has done by using the sprinkler in solar still. Figure 4 shows that use of sprinkler increases the productivity of solar still by 14%.

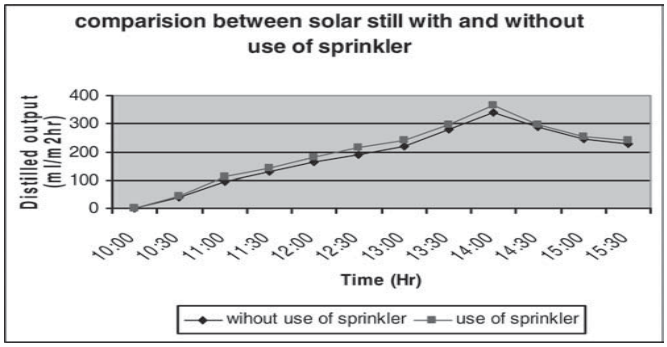

Figure 4: Use of Sprinkler in Solar Still

4.1.4 Cover Temperature

By reducing the cover temperature increase the productivity of solar still. Sharp increase in glass cover temperature (Tg) because of the effect of latent heat of condensation whoch having a significant role in raising the temperature of, a temperature much higher than ambient Temperature (Ta) and very close to the water temperature (Tw) could be the main reason of decreasing the rate of evaporation and then water productivity, such a high temperature might have a negative effect on the condensation process and the driving force of the convective mass content. Several studies have been done for cooling the glass cover temperature [29, 30, 31, 32]. There is a significant effect of the increased temperature difference (Tw - Tg) increase convective mass transfer and hence increase the productivity. It has been also show that slight increase of 3% in the solar still productivity is obtained by increasing the ambient temperature by 5 degree. [9]

4.1.5 Gap Distance between Evaporating and Condensing Cover

Reducing the gap distance between the evaporating surface and the condensing cover improves the solar still performance. The effect of gap distance is much important than the effect of cover slope. Reducing the gap distance will reduce the height of the walls of the cover slope and hence will reduce the shadowing effect of these sides. Also less time is elapsed by the saturated air to reach the condensing surface and therefore, continuous and quicker air movement in the still is occurs, Reducing the gap distance from 13.0 to 8 cm for the same cover slope and increase the output by 11 %. [10]

4.2 Improvements in Basin of Solar Still

Basin of solar still is a case in which brackish water is stored on which solar radiations are incident and brackish water is

converted in to potable water. It should have good absorptance but minimum Reflectance.

4.2.1 Basin with Different Depth of Water

GN TIWARI and At.al attempt has been made to find out the effect of water depth on evaporative mass transfer coefficient for a passive single-slope distillation system in summer climatic condition. The experiments have been conducted on a south facing, single slope, solar still of 30° inclination of condensing cover, in summer climatic condition for 24 h on different five days for different five water depths from 0.04 m to 0.18 m. [14]

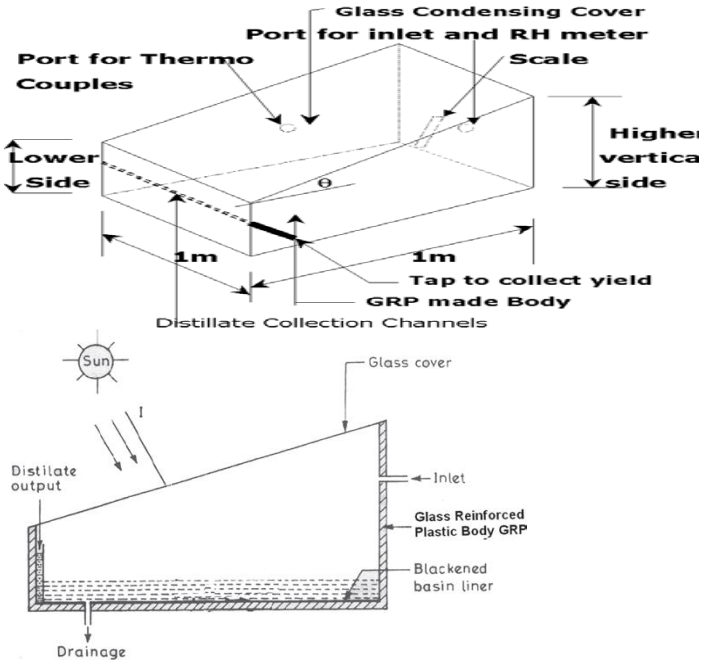

Figure 5: Conventional type solar still with GRP body [14]

The objective of the present paper is to study the behavioral variation in internal heat transfer coefficients with respect to the water depth in the still. It is understood that the heat transfer coefficients depends significantly on water depths. It is also observed that the nocturnal distillation is significant in the case of higher water depths because of reduced ambient and stored energy within it.

4.2.2 Types of Energy Storing Materials

A black material has advantage of storing more amounts of heat energy and increase the heat capacity of the basin to increase the absorption of solar radiation in basin. Glass, rubber, gravel, saw dust and sponge cubes are some materials which are used as energy storing materials. Experiments show that black rubber with 10 mm size increase the productivity of the deep basin solar still by 20 per cent and black gravel with 20 -30 mm size increases the productivity of a shallow basin still by 19%. [12]

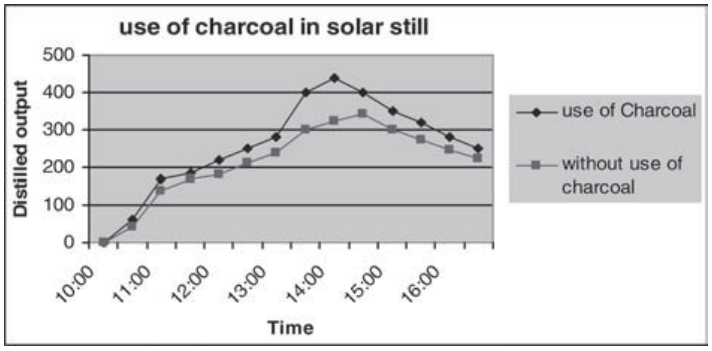

Figure 4: Use of Charcoal as Energy Absorbing Material

4.2.3 Types of Absorbing Materials

Different types of energy absorbing materials are used to increase the evaporation rate of the solar still. Rubber mate as well as charcoal is some materials which are used as solar energy absorbing materials. Charcoal is good material to increase the absorption capacity of the basin liner. [13]. Figure 4 shows the use of charcoal as energy absorbing material. It shows that 10% productivity is increased.

4.2.4 Use of Die in Basin

A research says that about 11 per cent of solar radiations received by the solar still basin is reflected back without using it. [11]. this loss can be minimized by using high heat absorption coefficient of basin as well as water increased. So a good method for increasing the absorption of the basin water by using dies. When die is used in solar still, hence the solar radiations are absorbed by the upper layer of water and temperature of upper layer of water increases and thus increase the evaporation rate. Different colour die are used in different proportion. Experiment shows that, by use of black nepthylamine dye at 172.5 ppm give higher increase in production of 29% has achieved. [11] Compared with red and dark green dye. And effect of dye is great on deep basin solar still than shallow water solar still. Figure 3 shows that black nepthylamine dye is more beneficial compared with violet die and red die by same concentration of 170 ppm. And output of solar still is increased by 15%.

Future scope of work on conventional type solar still:
If, we create a model of solar still with two or multi layer absorber plate and give the thermal contact together, then it utilize the maximum solar energy, covers the loss of solar radiation, increase the heat transfer area in the same $1m^2$ basin, and increases the productive output of solar still.

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