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DESIGN AND MATERIAL FOR A SOLAR STILL: A REVIEW

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ABSTRACT

Due to the rapid increase in population requirement for freshwater increases, day by day this purpose desalination method is used for freshwater production. Solar still is a device which is best for desalination due to its low cost and easy maintenance. But its disadvantage is low productivity. The aim of this paper is to provide a detailed overview of the different designs and materials of active and passive solar still to improve their efficiency and productivity. There are so many designs and materials that are more efficient and productive than conventional used designs and models. they are double slope solar still, pyramid shape solar still, spherical shape solar still, hemispherical shape solar still, and Tubular shape solar still. we can use different materials other than wood as basins which are galvanized steel, black aluminium sheets, copper sheet, bricks, concrete and many more.

Keywords: Solar Desalination Process; Evaporation; Condensation; Productivity; Efficiency.

I. INTRODUCTION

Water is the essential element for the sustainability of life on earth. Due to the rapid increase in demand for pure water which is a result of the high population and depletion of current pure water sources around the world. There is a need to find an alternative source of freshwater. As you know that Earth is surrounded by water which is about 71% of the earth. Out of which 96.5% is ocean water and the remaining 1% is available for human use which is Freshwater. To resolve this problem there is only one way which is the desalination of ocean salty water into freshwater.

Over the past years, there are so many improvements has been taken place in the field of design and material of solar still to improve its productivity and yield as compared to previous solar still models. In this paper, we reviewed various designs and materials used for the fabrication of different solar stills [1].

II. VARIOUS DESIGNS OF SOLAR STILL

There are different types of solar stills which are based on Geometry and the shape of a solar still is equipped according to various geometrical and climatical parameters. The geometrical parameters are the inclination of the cover plate or slope, length and thickness of the cover plate, water depth, and insulation layer thickness and are closely related to the geometry of the required basin [2].

There are some climatical parameters that also affect the geometry of solar still such as ambient temperature, wind velocity, solar radiation intensity, and Humidity. Sometimes operational parameters also affect the efficiency of solar still such as feedwater, preheating, and water salinity [3].

1. SINGLE SLOPE SOLAR STILL AND DOUBLE SLOPE SOLAR STILL WITH SINGLE BASIN

Single slope solar still is still which has a single slope or single cover plate to receive the solar radiation. Solar radiation is used to heat the water which evaporated in the basin of the solar still, condensed on the lower surface of the cover plate of the solar still and later collected in a collecting jar in pure water form. Single slope solar still has two types named Active single slope solar still and passive single slope solar still. Inactive solar still, there is an external source of heat to heat the water present in the basin of solar still whereas in Passive solar still there is no external heat source to heat the water present in the basin of solar still. In an experiment, Muhammad Ali Samee et al (2007) found that the calculated efficiency was 30.56% when the glass cover optimized angle was 33.3% with the required amount of cost efficiency with respect to rural communities [4].

Double slope solar still is a still which is equipped with two cover plates or two slopes to receive the maximum solar radiation when the sun goes from east to west. The efficiency of double slope solar still is more than the

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efficiency of single slope solar still due to receiving the maximum amount of solar radiation coming from the sun. M.S. EL-Sebaey et al (2013) investigated that the maximum daily productivity of 9.89 lit/m2 was obtained. when the external reflector is inclined at 60 degrees,1 cm is used as water depth in the basin of solar still (Egypt). The productivity of double slope solar still increases by 4.48% when the inclination of external reflector changes from 30 degrees to 45 degrees whereas it increases by 13.5% with the change in angle of external reflectors from 45 degrees to 60 degrees. when the angle of external reflectors changes from 60 degrees to 75 degrees the productivity decreases by 12.94% [5].

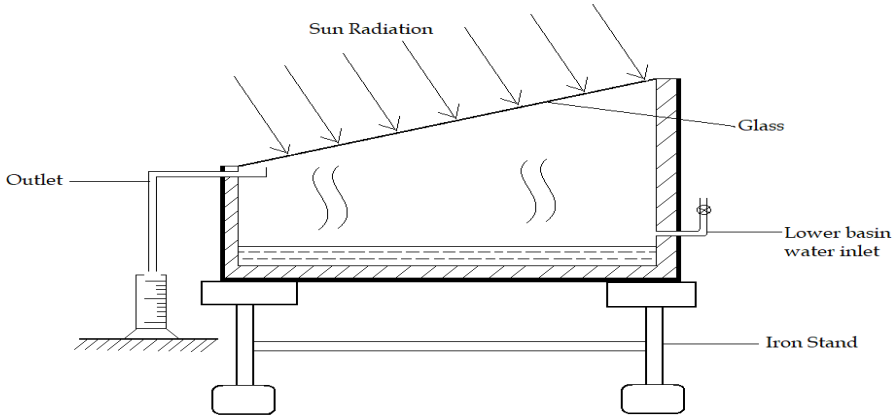

Figure 1: Single Slope Solar Still

2. SPHERICAL SOLAR STILL AND HEMISPHERICAL SOLAR STILL

Aspherical solar still has a slope or cover plate which is in spherical shape used to receive radiation from the sun. Due to its spherical shape the surface area for the incident radiation increases which increases the spherical solar still overall efficiency. Salima Karroute et al (2014) investigated that an asymmetrical spherical glass cover collects 4.62 L/m^2 of freshwater between 8 am to 5 pm whereas its theoretical productivity is around 3.12 L/m^2. There is the cooling of one side of the cover plate to increase the difference between the temperature of the cover plate and the temperature of the basin this increases the productivity of spherical solar still. The productivity of solar still is directly proportional to the difference in temperature between the cover plate and basin of solar still. Due to the spherical surface, there is an increase in evaporation and condensation phenomenon in solar still which is also responsible for an increase in productivity of solar still [6].

Hemispherical solar is still equipped with a cover plate or slope which is in a hemispherical shape. In hemispherical solar still basin associated with the hemispherical cover plate may be of rectangular or any other shape such as spherical, or hemispherical to hold the impure saline water which is desalinated with the help of hemispherical solar still into pure water. Basel I. Ismail et al (2009) found that the daily yield obtained was about 2.8 to 5.7 L/m^2 of absorber area. With the use of hemispherical shape solar still, there is also an increase in daily efficiency by 33%. According to the experiment solar still can convert 50% of input saline impure water into distilled water output. It was also found that with increasing water depth there is a proportional decrease in daily efficiency [7].

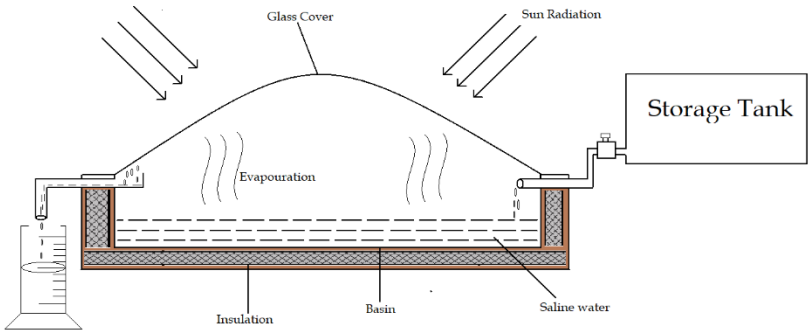

Figure 2: Hemispherical Solar Still

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3. TUBULAR SOLAR STILL AND PYRAMIDICAL SOLAR STILL

Tubular solar still has a transparent cylindrical tube which is associated with the rectangular absorber that constitutes Tubular solar still. It follows the same principle of condensation and evaporation of water to obtain pure water there is the only difference in the shape of the cover plate which is in the shape of a cylinder. The solar radiation comes through a transparent tubular cover plate which is used to heat the saline water and the whole process continues till we get the freshwater. Amimul Ahsan et al (2012) investigated that the use of polythene film was better than vinyl chloride sheet which is heavy and more costly.It was found that the average evaporation and condensation mass transfer coefficients were about 0.045 m/s and 0.03m/s [8].

Pyramidical solar is still equipped with a top cover plate in the shape of a pyramid. It has two categories named triangular pyramid solar still and square pyramid solar still. It is used over conventional solar still because it has a lot of benefits in pyramid solar still there is no shading by the wall on the water surface or less as compared to conventional solar still. Ravishankar Sathya Murthy et al (2014) investigated that daily productivity increases by 8% and 15.5% when the surrounding air velocity is 3 m/s to 4.5 m/s [10].

4. TRIANGULAR SOLAR STILL AND RECTANGULAR SOLAR STILL

Triangular solar still is a still which has a top cover in the shape of a triangle that is used to receive solar radiation coming from the sun. The triangular solar still consists of two triangular shape cover plate which is supported by a glass supporting piece with an absorbing plate which is also in a triangular shape. Rajendra Prasad et al (2021) investigated that with the help of triangular solar still the maximum yield obtained was 3.24 kg/m^2 and there was also an increase in efficiency by 39.24%. It was also found that there was an increase in efficiency by 12.96% with the help of a modified absorber plate [11].

Rectangular solar still is a solar still which is equipped with a top cover plate which is in the shape of a right-angle triangle and rectangular shape basin. The construction of this type of solar still is easy and low in cost when compared to other types of solar still. It can be easily installed and maintained. Arunabh Saikia et al (2018) investigated that the maximum output obtained was 662 ml of pure distilled water on a sunny day. It was also found that water yield in the month of February, March, and April was 400-410 ml. Abdallah et al (2015) found that 15 degrees are the best inclination for single slope passive solar still with respect to its yield and efficiency when compared to the different inclination angles of the cover plate such as 30 degrees and 45 degrees [12].

III. MATERIAL USED TO INCREASE THE ABSORPTION PROPERTIES

Bilal A. Akash et al carried out an experiment on a single basin double slope solar still which has a 3 m^2 basin area which is made up of stainless steel and a glass cover over it at an angle of 25 Degrees. The entire assembly was made airtight with a rubber gasket. In which three materials are used and compared the productivity for the same conditions. The freshwater productivity by black dye, black ink and black rubber mat is about 60%, 45% and 38% respectively [13].

K. Kalidasa et. al. carried out an experiment he used glass for cover because it has good transmittance, and wetting properties for minimising the loss of solar radiations during the condensation process. They use a mica sheet as a suspended absorber for surface heating [14].

R. Samuel et. al. worked with different wick materials with different absorber plates. They used polystyrene sponge, water coral fleece and wood pulp paper with a flat absorber, rectangular stepped absorber and wire mesh absorber. They get the productivity of 71.2% and 48.9% when coral fleece with a stepped wire mesh absorber was used [15].

Kalidasa et.al. fabricated single and double basin double slope solar still with identical models for insulated and un-insulated conditions. The varying water depth range is 1 to 5 cm. The 8.12% and 17.38% of insulated and un-insulated double basin solar still are more productive than a single basin still [16].

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IV. COMPARISON

Figure 3: Bar graph representing productivity of various solar stills

DBGSS – Double Basin Glass Solar Still

SSS – Spherical Solar Still

HSS – Hemispherical Solar Still

PSS – Pyramidical Solar Still with Evacuated tubes

V. CONCLUSION

It has been found that the productivity of Pyramidical solar still coupled with Evacuated tubes is maximum when compared to Double basin glass solar still, Spherical solar still, and Hemispherical solar still. The total yield for Pyramidical solar still coupled with evacuated tubes is 6928 mL/m^2 which is higher as compared to the total yield obtained from hemispherical solar still, Spherical solar still and Double basin glass solar still which are 3659 mL/m^2/day, 2900 mL/m^2/day, and 2300 mL/m^2/day.

The use of black dye increases the productivity of solar still up to 60%. For surface heating and insulation to heat loss the use of mica sheet and rubber are the best ways to get high productivity because it has high heat absorbing and high heat storing properties. The wick material increases the productivity of solar still by 31.2%. If we use coral fleece wick material with a stepped wire mesh absorber it increases the productivity by 71.2%.

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