Design and Fabrication of Solar Distillator

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Abstract - Availability of drinking water is one of the major challenges faced by our modern society. There are certain locations throughout the globe where there is scarcity of fresh drinking water but availability of brackish or saline water. This available water resource can be used for harnessing usable water to meet the present drinking day water requirement. Due to population explosion demand of fresh water (potable water) has increased from 15-20 liters/person/day to 75-100 liters/person/day.

Water reservoir of fresh water gets polluted due to the mixing of industrial effluent and sewage. There is an important need for clean, pure drinking water in many developing countries. Distillation is one of good method to obtained fresh water.

Solar distillation is a process which can be helpful in this regard. This principle uses the solar energy to extract out the drinking water from the saline water. This is an eco-friendly device using a renewable source of energy.

Keywords - Distillator, Sealant, Insulation and Double slope.

I. INTRODUCTION

SOLAR DISTILLATION

A Solar still works on the principle of solar distillation. Saline water is filled in the basin of the solar still and then solar radiations are allowed to fall on it. The distillator is designed so that it is subjected to maximum amount of solar insulation and an efficient amount of radiations get trapped inside it. This increases the internal temperature of distillator causing the saline water to evaporate leaving behind all the insecticides, herbicides, bacteria, viruses etc. These water droplets get attached to the glass cover of the solar still. Further, on condensation these droplets gets collected in the condensate channel due to the inclination provided to the glass covers. Finally fresh water is obtained.

SOLAR STILL

Solar still is a simple device which can convert available water or brackish water into potable water by using solar energy.
1. Passive solar still
   a. Single slope
   b. Double slope
2. Active solar still
   a. Single slope
   b. Double slope

COMPONENTS OF A DOUBLE SLOPE SOLAR DISTILLATOR

1. Basin
2. Black Liner
3. Transparent Cover
4. Condensate Channel
5. Sealant
6. Insulation
7. Supply and Delivery System

Fig 1.1 : Typical double slope solar still
II. WORKING PRINCIPLE

A solar still is a very simple way for distilling water, which is powered by the heat of the sun. Impure water is inserted into the container, where it is evaporated by the sun through clear glass. The pure water vapour condenses on top and drips down to side, where it is collected and removed. It consists of an insulated black painted basin where impure water stands at shallow depth. A sloping cover of glass, supported by an appropriate frame, covers the pan and is sealed tightly to minimize vapour leakage. A distillate through runs along the lower edge of the glass to collect the distillate and carried out of the enclosure.

GREEN HOUSE EFFECT

The incoming radiation from the Sun is mostly in the form of visible light and nearby wavelengths, largely in the range 0.2–4 μm. Almost half the radiation is in the form of visible light. The Earth receives energy from the Sun in the form UV, visible, and near IR radiation, most of which passes through the atmosphere without being absorbed. Of the total amount of energy available at the top of the atmosphere, about 50% is absorbed at the basin surface & the brackish water. Since the surface becomes warm, it radiates far IR thermal radiation (8–25 μm) that consists of wavelengths that are predominantly much longer than the wavelengths that were absorbed. Most of this thermal radiation is absorbed by the inside atmosphere of the setup and re-radiated both upwards and downwards; that downward radiated radiations are absorbed by the basin surface. This trapping of long-wavelength thermal radiation leads to a higher temperature inside the setup. Hence, it causes green house effect inside the experimental setup.

III. DESIGN OF EXPERIMENT SET UP

DESIGNING PARAMETERS

We have identified the main three parameters namely first climatic parameters under which solar radiation, Ambient Temperature, Wind speed, outside humidity and sky Conditions are considered under climatic parameters play important roles like that second parameter is design parameters under which single slope or double slope, glazing material, water depth in basin, bottom insulation, orientation of still, inclination of glazing, spacing between water and glazing and solar still are considered under design parameters and third parameter considered is operational parameters under which water depth, preheat of water, coloring of water, salinity of water, rate of algae growth, input water supply and arrangement (continuously or in batches) are the parameters considered.

DIMENSIONS OF SOLAR STILL

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameters</th>
<th>Double Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Area of Basin</td>
<td>0.5m²</td>
</tr>
<tr>
<td>2</td>
<td>Height of Basin</td>
<td>0.06 m, at sides 0.1939 m, at center</td>
</tr>
<tr>
<td>3</td>
<td>Area of Glass</td>
<td>0.2585 m²</td>
</tr>
<tr>
<td>4</td>
<td>Thickness of Glass Cover</td>
<td>0.003 m</td>
</tr>
<tr>
<td>5</td>
<td>Angle of Glass</td>
<td>15°</td>
</tr>
<tr>
<td>6</td>
<td>Thickness of Insulation</td>
<td>0.004 m</td>
</tr>
<tr>
<td>7</td>
<td>Height of Still from Ground</td>
<td>0.45 m</td>
</tr>
</tbody>
</table>

DESIGN OF WATER BASIN

- Assume the basin area to accommodate 30 kg of water i.e m=30 kg
- Density of water, ρ=1000 kg/m³
- Volume of water = m/ρ = 30/1000 = 0.03 m³
- Volume of basin = vol.of water
  \[ V_{basin} = 0.03 \times 10^6 \text{ cm}^3 \]
- Basin is rectangular type, \( V_{basin} = \text{length} \times \text{breadth} \times \text{height} \)
- By fixing length, \( l = 100 \text{ cm} \)
  Breadth, \( b = 50 \text{ cm} \)
  So, height, \( h = 6 \text{ cm} \)

FABRICATION OF SOLAR STILL

Procurement of material: For glazing glass is used and thickness of 3mm is selected, black paint is used as the liner, M seal is used as the sealant, GI sheet of 18 gauge thickness is used for fabrication, Teak wood is used for making the frame

DEVELOPMENT OF BASIN

The GI sheet is properly marked with the required dimensions then by using power shear machine & hand shear the sheet is cut into the appropriate shape, three holes are made on the sheet of half inch each for water supply & water collection, holes are made by using the drilling machine, then the sheet is folded at the required markings by using the folding machine.
DEVELOPMENT OF CHANNEL

Sheet of required dimension is first cut out, and then it is folded by using the folding machine.

DIMENSIONS USED FOR FABRICATION

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</tr>
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<td>2</td>
<td>Thickness of Glass</td>
<td>0.003 m</td>
</tr>
<tr>
<td></td>
<td>Cover</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Angle of Glass</td>
<td>15°</td>
</tr>
<tr>
<td>4</td>
<td>Length of channel</td>
<td>0.02 m</td>
</tr>
<tr>
<td>5</td>
<td>Height of channel</td>
<td>0.02 m</td>
</tr>
<tr>
<td>6</td>
<td>Area of Basin</td>
<td>0.5 m²</td>
</tr>
<tr>
<td>7</td>
<td>Diameter of hole</td>
<td>0.5''</td>
</tr>
</tbody>
</table>

CLEARANCE ON BASIN WALL

A clearance of 2cm was given on the basin side walls, this extra height will keep the condensate channel above the water level, and this will also act as an indicator for the water’s required level.

CLEARANCE ON TRIANGULAR WALL

A small portion is cut out from the top of the triangular wall this is meant for providing a support while fixing the double slope glass.

ASSEMBLY

Finally the channels are attached to the folded walls of the solar still by welding. The gaps are filled by applying M seal. The frame is made by using teak wood for holding the glass. This is fixed to the still by providing support at the walls. The glass is made fixed at one side & made detachable on other side for cleaning purpose.

HEAT RESERVOIR

A heat reservoir is made out of GI sheet with 110 cm length, 60cm breadth, and 30cm height. This hollow cuboid is filled with sand that acts as the heat absorbing material during the day time. Sand radiates heat during the night time continuing the distillation process even in the absence of solar radiation.

SET UP INSTALLATION

The solar still fabricated is installed in a suitable location where appropriate sunlight is available. The set up is placed along the north west direction so as to counter the sun’s motion. Fillets are provided at the two opening’s for water collection and a pipe is inserted at the back of the set up for water inlet. The water reservoir is kept at a particular height for the steady flow of the water. While conducting the experiment without insulator the still is kept on the ground & while conducting with insulator the still is kept on the heat reservoir and insulated from all sides by the help of cotton. Cotton is packed in plastic covers and then used as an insulator in order to make it weatherproof. Now the setup is ready for conducting experiment

DECIDING THE DIRECTION AND ANGLE OF INCLINATION

The angle and direction of installation is also of great importance as it will affect the efficiency of the solar collector. Naturally you want the collector to receive the maximum amount of sunlight each day and throughout the year. As a general rule if you are in the Northern Hemisphere then the collector should face south and if you are in the Southern Hemisphere then the collector should face north. See diagram below.

![Diagram of Direction and Angle of Inclination](image)

The angle at which you mount the collector should roughly correspond to the latitude of your location.

EXPERIMENTS WITHOUT INSULATOR

In this phase water is supplied to the solar still from the reservoir at about 9 am in the morning. Then the setup is exposed to sunlight for the rest of the day. Water starts evaporating due to rise in temperature and the vapor’s starts sticking to the glass walls of the still. After condensation these vapor’s starts rolling down due to the slant nature of the still. This water gets collected in the condensate channel and is recovered from the system at regular intervals. Once the water is collected during the afternoon time & again at the evening time. The amount of water collected is then measured and then compared with the theoretical value and hence the loss occurred can be calculated.

EXPERIMENTS WITH INSULATOR

Initially the setup is covered with cotton on all the sides & then the experiment begins with the similar
procedure as mentioned above. The distilled water is collected once in the afternoon then in the evening, and finally once again in the morning. This is because the wick material and the heat reservoir keep the distillation process charged even in the night time. Water obtained is measured and a comparative study is made between water obtained without insulator and with insulator.

IV. RESULTS AND DISCUSSIONS

A. EFFICIENCY INCREMENT

Productivity without insulator for a period of 5 days –

<table>
<thead>
<tr>
<th>DAYS</th>
<th>PRODUCTIVITY (ml/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>460</td>
</tr>
<tr>
<td>2</td>
<td>450</td>
</tr>
<tr>
<td>3</td>
<td>450</td>
</tr>
<tr>
<td>4</td>
<td>480</td>
</tr>
<tr>
<td>5</td>
<td>420</td>
</tr>
</tbody>
</table>

Average productivity without insulators = \( \frac{460 + 450 + 450 + 480 + 420}{5} = 452 \) ml/day

Productivity with insulator for a period of 5 days –

<table>
<thead>
<tr>
<th>DAYS</th>
<th>PRODUCTIVITY (ml/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>510</td>
</tr>
<tr>
<td>2</td>
<td>490</td>
</tr>
<tr>
<td>3</td>
<td>480</td>
</tr>
<tr>
<td>4</td>
<td>500</td>
</tr>
<tr>
<td>5</td>
<td>480</td>
</tr>
</tbody>
</table>

Average productivity with insulators = \( \frac{510 + 490 + 480 + 500 + 480}{5} = 492 \) ml/day

Net increment in productivity = \( 492 - 452 = 40 \) ml/day

Percentage increment = \( \frac{40}{452} \times 100 = 8.84 \% \)

Hence, the percentage increase in the solar distillation process is 8.84 %

B. PH TEST

COLOUR COMPARISON

The water sample collected for the experiment is subjected to colour comparison pH test. A special paper called alkazones paper strip is used in this regard. This paper is made to dip in the water for about 2 minutes. The corresponding colour change is noted and its pH value is obtained from the chart. Then the water obtained after distillation is also subjected to similar procedure & it’s pH value is obtained.

<table>
<thead>
<tr>
<th>WATER SAMPLE</th>
<th>COLOUR</th>
<th>pH VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRAKISH WATER</td>
<td>PURPLE</td>
<td>8</td>
</tr>
<tr>
<td>DISTILLED WATER</td>
<td>BLUE</td>
<td>7</td>
</tr>
</tbody>
</table>

The water initially taken for the distillation process was basic in nature with pH value 8 & was unfit for drinking. After being distilled the pH value reduces to 7 which is neutral & fit for drinking purpose.

V. CONCLUSIONS

- Productivity increases with the use of wick materials (cotton) acting as insulators.
- Productivity increases with inside temperature of the setup.
- Use of sand makes the distillation process possible even at night time.
- The percentage increase in the solar distillation process due to use of insulator is 8.84 %.

Distillation makes the water fit for drinking and free from microbes and other impurities.
V. REFERENCES


