Double Slope Solar Evaporative Distillation System

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Abstract -*Distillation is a process of purifying a liquid by separating the component substances from a liquid mixture by heating and cooling. Distilled water is an essential part of chemical and biological field includes institutions, pathological laboratories, industries etc. A simple distillation process involves heating of water using and immediate condensation of the vapour in a condenser. Conventionally heating is done by lead-acid batteries or fossil fuels. Seeing the rapid depletion of conventional sources of energy over the decades, in this project, we have decided to use a non – conventional energy source as solar energy for the distillation of water. The main objective is that to use double still solar distiller in passive condition and analysis the distillation quantitatively and qualitatively and use it during absent of sunlight and see is there any distillation occur or not. The project involves design and fabrication of double slope solar still and checks its effectiveness on daily basis to cater to the needs of lead – acid battery retailers and thus, saving on conventional sources of energy and also reducing the cost price of distilled water for the retailers. Solar energy is used for heating the sample water and evaporates it which is condensed at the inner surface of the double slope glass, which is placed at an angle of the horizontal. Due to an inclination of the glass, the condensed vapour droplets slide down the inner surface of the glass and get collected in the delivery flask through a delivery pipe.*

Key Words: Distillation, evaporation, condensation, minimum ions pick, evaporative distillation, drop by drop condensation, recuperative heat transfer, *green house effect*, etc…

1. INTRODUCTION

The project aim to design double slope solar still, fabricate with suitable material and analyzed its effectivity quantitatively and qualititatively. Requirement of distilled water is continuously increasing along with mordenization [4]. For some specific work deionization water is essential. For distillation a source of heat is required. Here we are using solar energy as a source of heat. Soilar energy is a renewable energy with some advantages and disadvantages. Due to replacement of the conventional energy as a heat source like lead-acid batteries or fossil fuels the total cost for distillation is reduced [5]. There is no any chances of emission pollution. Avalibility of solar energy is also high as compare to others. But at the same time it is only usable at day time, more specifically depend on the sun [3].

The project involves designing and fabricating a solar still which can produce sufficient amount of distilled water on a daily basis. It also involves selection of material and positive design for minimum ions pick up conditions. We use double slope solar still construction for increase the output. Solar energy is used for heating the sample water and evaporates it which is condensed at the inner surface of the double slope glass, which is placed at an angle of the horizontal. Due to an inclination of the glass, the condensed vapour droplets slide down the inner surface of the glass and get collected in the delivery flask through a delivery pipe.

2. METHODOLOGY

We use passive double slope evaporative type solar distiller [1]. Passive system due to only involves the solar energy for heating. We use double slope symmetric model for higher output [2].

3. Design and Fabrication

The solar radiation gets absorbed by the water in two major ways.

1. The green house effect: - The solar radiation enters the storage tank through the glass while having a very high frequency and low wavelength. This radiation gets absorbed by the water and the storage tank too. But the radiation emitted by the glass and the radiation emitted by the storage tank that would have passed through the glass cannot escape through the glass because of the lower frequency and higher wavelength radiation by the lower temperature water and storage tank.

2. Recuperative heat transfer: - The storage tank works as a recuperative heat exchanger that absorbs the heat from solar radiation and transfer it to the stored water in the storage tank.

Absorbing the heat from solar radiation the stored water in the storage tank evaporates and goes straight up to the Condenser glass plates. The glass, though not a good conductor of heat stays comparatively colder than the water vapour due to convective heat transfer to the atmospheric air. The water vapour gets condensed at the inner side of the glass by the process of drop by drop condensation and by the slope drops to the collector plates. Collector plates are to hanging plastic sheets of nearly 9mm width which are attached one side to the condenser glass plates and the other side hanging. The collector plates are a little short in length than the condenser glass sheets. The use of the collector plates on each of the condenser glass sheet is to bring the condensed distilled water to the collecting channel and also decreasing the contact of distilled water with galvanized iron sheets to minimize the ion pick up.

The collector channels are made at two sides of the tank to collect the dropping distilled water from the condenser glass sheets over the collector plates to the outlet. The collector channels are made by inclined glass plates. Glass plates are used for making the collector channels to minimize the ion pick up. The two collecting channels from two sides come together at another side and ends at the outlet.

Even the outlet is covered with plastic sheet at the inside to decrease ion pick up. From the outlet the distilled water gets collected in a collecting bottle.

Used material for tank is GI Sheet, Transparent Glass, Metal pipes, Pipe joints – straight joint, L-joint, Reducer – 2" to 1", 1" to ¾", M-seal, Cello fin, Net, White sealant, Cap.

Tank was made by welding. The proper dimension is given as follows:

Tank size = 1 m × 0.76 m × 0.61 m.

Glass plate size=1 m × 0.56 m × 0.005 m.

Fig -1: Inner view of tank

Fig -2: Complete assembly of the distillation system

4. RESULT

Result is as follows

Table -1:

Date	Amt. of brackish water (m^3)	Time			Inner surface water temp (^0C)	Inner surface water temp. (^0C)	Amt. of Distilled water (m^3) [Eye estimationdue to incomplete collection arrangement]
		Initial	Final	Duration			
03.05.18	0.005	2.00 pm	4.00 pm	2 hours	27	26	0.00060
05.05.18	0.005	1.00 pm	3.00 pm	2 hours	27	25	0.00055
16.05.18	0.005	7.30 pm	8.30 pm	1 hour	25	23	0.00015

4.1 Calculation

- **Assumption:**

The operating hours of the double slope solar evaporative distillation system is 8 hours per day.

- **Objective:**

10liters of distilled water a day

- **Calculation:**

Let solar radiation intensity = i W/m^2

Area = 1 X 0.5 m^2 (Width is taken less to account for working area only)

Average solar radiation = i/2 W/m^2

For 8 hours operation pert day

Total solar radiation = i/2 X 1 X 0.5 X 8 x 3600 J

Now due to reflectivity some amount of solar radiation is reflected back, but due to green house effect the re-radiation from the inner bottom plate of the storage tank is somewhat reflected back.

Thus a very low reflectivity is assume d have

Let, reflectivity = 0.03

Finally absor4bed solar radiation = i/2 X 1 X 0.5 X 8 x 3600 X (1-0.03) J = 6984 i J

Transmissivity is assumed to be zero as metal plate are used i = 1353 W/m^2

Finally absorbed solar radiation = 6984 X 1353 = 9449352 J = 9449.352 kJ

- **Evaporation rate calculation:**

The evaporation rate is calculated here as Kg per day

Let, at the pressure inside the tank, the specific enthalpy of evaporation of water = h_{fg}KJ /kg Let the boiling point of water at pressure inside the tank = t^0C

Let the enthalpy needed to increase the temperature of the feed-water to the boiling point temperature of the water at a pressure inside the tank = h_f kJ/kg

The total enthalpy taken by the water = $(h_g - h_f)$ kJ/kg

As the water is not superheated because being saturated it becomes light and goes up and reaches the condenser glass plates where the vapour condenses. Thus no superheating of vapour is assumed here.

Evaporated water = 6984 i/$(h_g - h_f)$ kg = 944.352/$(h_g - h_f)$ kg

Let pressure inside the storage tank = 1 atm = 1 bar = 10^5kpa

Let the atmospheric temperature is little above the temperature of the feed-water

Let the inlet temperature = 27^0C

h_f= 1 X 4.2 X (27-0) KJ/kg = 113.4 KJ/kg

h_{fg} = 2257 + 417.04 KJ/kg b= 2674.04 KJ/kg

= $(h_g - h_f)$KJ/kg

Total specific enthalpy taken by water

= 419.04+2257.0-113.4kJ/kg = 2562.64kJ/kg

Evaporated Water= 9449352/2562.64kg = 3.687kg

From the view point of objective theoretical volumetric efficiency = 3.687/10 * 10^{-3} * 10^3

= 0.3687=36.78%

No factor of safety is assumed here due to high enthalpy value.

5. Conclusion

The Theoretical Estimated Amount of condense water equals to 3.678kg.

The Practical amount of condense water meets to be seen continually with weather changes and others atmospheric variable changes.

Distillation of water using solar still basin is the most economical method to get portable drinking water. Salt, bacteria and other impurities are contaminated which are to be removed completely in the distillation process. The solar stills are best technology for living beings and environment because they do not need electricity for processing, no running water is required, lifetime is more and easy to maintain.

Due to this particular project not only we learn more things about non-conventional energy and solar still we also come across a different experience about entire process from start to end of making a practical engineering object.

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