Design of Solar Powered Water Distillation Plant

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Abstract: Residing in Konkan region, we have abundance of the solar energy and the sea water, which are the sources of Non-conventional Energy. The main objective for choosing this project is to harness these Non-Conventional Sources and make the availability of Distilled Water for Industries and other purposes. As these sources, Solar energy and Sea water are readily available free of cost in surrounding areas, it makes the whole process Cost-effective. So the main aim behind this research is to make a Water Distillation Plant that can be able to purify water from any source. Also the plant should be relatively cheap, portable and dependent only on the Non-conventional energy resources. To achieve this, a plant is designed having a parabolic Solar Collector with a specially designed Distillation device. Solar energy from the Sun, in form of radiations are focused and concentrated onto the Receiver pipe with the help of parabolic collector. The water inside the pipes is heated, converted into vapours and then sprayed on Designed Distillation system where it is re-condensed to make portable distilled water. Theoretical analysis of the heat and mass transfer mechanisms inside this solar still has been developed. This plant is used to enhance the Overall Efficiency with help of increased amount of solar radiation and with rise of feed water temperature.

Keywords- Condenser, Evaporator, Renewable Energy, Solar Collector, Solar Radiations, Water Distillation.

I. INTRODUCTION

Water is the essential for humans along with food and air. But, unfortunately, there is very less percentage of water which is safe to drink without any filtration process. Hardly 1% of the Total water present is fresh, without any impurity and remaining water bodies are highly contaminated and are hazardous for human. For this reason, purification of water is extremely necessary. Moreover previous purification systems were easily damaged. This scenario was a great challenge in front of us and to be prepared for it is equally important. Various attempts were also made in order to purify the water & tackle this hazard, but weren't that successful. Fortunately there is a solution to these problems. It may not be the technology or technique that can eradicate the contaminants and pollutants in one step but are simple, cost-effective yet ecofriendly. It is made possible with the help of solar energy. [5]

Distillation is the process that proves to be beneficial in purification of water. This mainly requires solar radiations as the Input energy. The water is made to be evaporate and is easily separated from the contaminants in form of water vapour. These vapours are then condensed in order to get pure water. [6].

Solar powered Distillation of water is a technology with very large background and was in existence nearly 2000 years ago. It was basically discovered to obtain salts, rather than pure water. To be precise, actual use of solar powered systems began in sixteenth century itself. A considerably large solar still was produced in the year 1875 to provide water to the underground mining workers. Pure water in huge quantity was produced during the Second World War when nearly 3,00,000 plastic bottles were made to be placed for military use.[2]

II. NEED AND WORK

Our plant focuses on conversion of most of the water which presently is in inappropriate form, to convert into edible and fit for use form. After doing research, we have highlighted following needs:

- Efficient production of almost 5 liters of drinkable water per day.
- It should be able to purify water from nearly all water sources, including oceans.
- Comparatively at cheap price to remain in contact with large audience.
- It should consist of User friendly Interface.
  - It should be easy to operate.
  - It should be able to provide clean drinking water without any use of an external energy source.
  - It should be compact and easily portable.

Our motto is to achieve this goal by utilizing and converting the incoming radioactive power of the sun's rays to increase the temperature and then distill it from toxic undrinkable water into clean, pure and safe for drinking water. A solar collector is used efficiently to focus and then increase the solid angle of incoming beam radiation, enhancing the overall efficiency and enabling high water quantity to be purified.

III. DESIGN

A.Design of distillation system

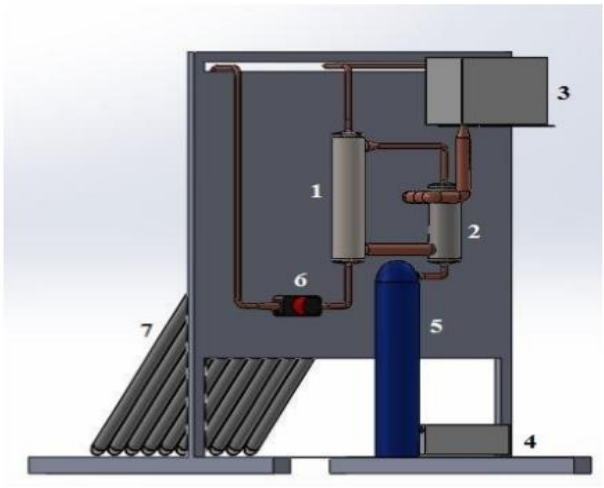

Fig.1: Design of Solar powered Distillation Plant.

- **Components**:-

1. Evaporator.
2. Condenser.
3. Storage Tank for Saline Water.
4. Storage Tank for Distilled Water.
5. Filter.
6. Pump.
7. Solar Collector.

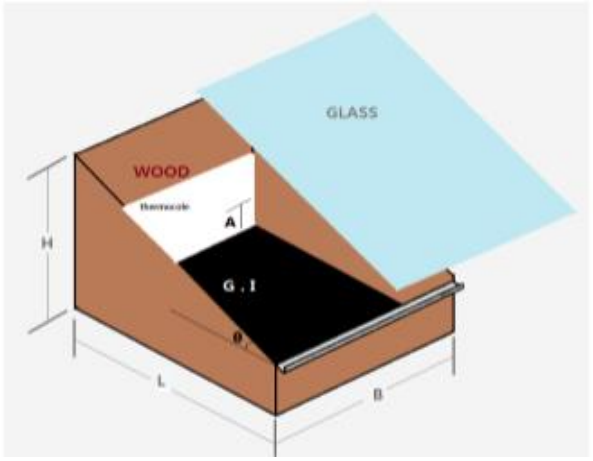

Fig. 2: CAD MODEL

IV. DESIGN SPECIFICATION

[1] Evaporator:

A device in a process used to convert the liquid form of a substance (like water) into its gaseous or vapour form.

- Material used: Aluminium foil, Copper.
- Shell & Tube Type Evaporator
- Dimensions:
- Overall heat transfer coefficient =300 W/m2K.
- Area for the evaporator = 0.13 m2.

Length of the Evaporator= 62cmA = useful piston area in cm= = D2 x n/4

Q= 5 lit/hr

mw = 5*10^ (-3) m^3

Latent heat of vapour:

= Latent heat * mw

= 2257.9*5

=11289.5 KJ/hr

=3.1359 kW

- (E)evap = 1.5 * 3.1359 = 4.7 KW

[2] Condenser:

A device used to condense the substance from its gaseous to liquid state by lowering the Temperature.

- Type of Condenser: Shell & Tube.
- Material used: Copper-Nickel Alloy, Stainless Steel
- Dimensions:
- Diameter: 13.4 cm.
- Overall heat transfer coefficient = 1000 W/m2K.
- Heat transfer area = 0.066 m2.

Condenser Heat Required:

$h_{sup} = h_g + C_p (T_{sup} – T_{sat})$

$= 2257.9 + 2.88*(T_{sup} - 100)$

Total heat lost,

$= hsup* m_{steam}$

$E_{condenser} = 1.5 * h_{sup} * m_{steam}$

Evaporator Balancing:

- $M_{o*} h_{cp*} dT* T_{sup}$

$= m_w *c_{pw*} (373- T_{amb}) + mw*(latent H.V.) + m_{w*(}Cp)$ Steam*(tx-373)

= (5/3600) * 4.187 * (373-T1) + (5/3600)* 2257.9 + (5/3600) *2.88(tx-373)

- Condenser Balancing
- Heat lost by steam = Heat gain by feed water

A+B+C

= (5/3600) * 4.187 * (T_{amb}- T_1)…. T_{amb} =30 C

Solar Collector:

Solar Collector is any of the various devices used for the absorption of solar radiation for heating of water or for production of electricity.

•Type of Collector: Conical collector

•Material used: Aluminium and Glass.

•Base Conical System- 0.64mm.

•Outer Layer- Thickness of 22 gauges.

- Diameter of Cone- 800mm.
- **Solar Collector**
- Total heat required = E_{evap} * 1.5

= 4.7 * 1.5

= 7.05 KW

- Hence, Total heat required = Area * Solar Radiations

[3] Pumps:

Pumps are used to transport fluids by conversion of Rotational kinetic energy to Hydrodynamic energy of fluid flow.

Centrifugal Pump:

The pump will be connected to the closed loop between the solar Collector and the evaporator.

This pump is used to lift the water.

- Motor capacity: 0.5 HP

[7] Other Requirements:

- Storage Tank: Cylindrical tank
- Capacity: 10 litres (for storing Water)
- Capacity: 6 litres (for storing Distilled Water)
- Piping System: Standard piping system.

V. ECONOMIC ANALYSIS

The efficiency of the plant and the saving of resources using our specially designed Water Distillation plant in terms of money can be accounted directly with help of the total cost required to distill the water on daily basis and this has been around INR 4,340/- monthly. However, in order to save other fuels, analysis was made for determining approximate consumption of different fuels that can be used for the exact purpose. By optimizing all these, the estimated savings of energy in terms of INR is 60,000/- annually.

With the help of this modified solar water distillation plant, an individual will be able to save the fuel and money as well. Thus it will make the system cost-effective and also help to maintain the complete process pollution free. It will also have the best use of solar energy at single place with almost negligible cost for the resources.

VI. MERITS & LIMITATIONS

- **Merits:**

1. It is able to produces pure water.
2. There are no moving parts.
3. No need to any energy types.
4. No skilled operator required.
5. Local manufacturing and maintenance.
6. Low production cost.

- **Limitations**:

1. Design is more complex.
2. Initial cost is more for whole system.

VII. RESULT AND DISCUSSION

DDistillation of water using solar energy will be an effectively used method for providing drinkable water to users. Also the abundant amount of solar energy makes the process cost negligible. Conical shape solar collector and modified distiller were designed to take advantage of the solar energy available in these regions. During the complete activity, the factors that can enhance single day productivity along with considering cost to be kept minimum were explored. Also other components capable of affecting the output were also analysed. It also included the effect of Surface area on productivity, overall thermal efficiency, and the solar radiations. So the final design adds numerous features to increase the Efficiency of a traditionally used Solar Still.

VIII. CONCLUSION

In regards to our Solar Water Distillation concept, we have come to the conclusion of an overall design and concept of our final assembly. The enhanced solar water collector has undergone several iterations to produce maximum potable water production. The overall basic geometry of the solar water distillation comprises of:-Distiller with Heat exchanger, Conical solar collector, etc. These are the pioneering components that make it possible for converting contaminated water into Clean, drinkable water through Distillation process. This is engineered through a dynamic process of solar energy, evaporation, and condensation. So our system allows for the production of 15-20 liters of purified water daily within Ideal solar conditions.

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