DESIGN AND DEVELOPMENT OF IMPROVED WATER DISALINATION UNIT USING SOLAR CONCENTRATOR

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Abstract - Clean drinking water is the basic necessity for every human being, but about 1.1 billion people in the world lacked proper drinking water. There are many different types of water purification processes such as filtration, reverse osmosis, ultraviolet radiation, carbon absorption, but the most reliable processes are distillation and boiling. Water purification, such as distillation, is especially important in regions where water resources or tap water is not suitable for ingesting without boiling or chemical treatment. In design project It treats the water by combining different methods such as Filtration, Distillation and a technique called concentrated solar power (CSP).Distillation is literally the method seen in nature, whereby: the sun heats the water on the earth's surface, the water is turned into a vapor (evaporation) and rises, leaving contaminants behind, to form clouds. As the upper atmosphere drops in temperature the vapors cool and convert back to water to form water. In this project distillation is achieved by using a parabolic concentrator which boils water at high temperature. The steam will go through the pipe into the condenser and steam will be condense. The distilled water is then collected in a water container at a focus of parabolic concentrator where distillation process is done. Another important feature of designed project is the solar tracking of a parabolic mirror which increases the efficiency of a parabolic concentrator.

Key Words: Parabolic concentrator, solar distillation, solar tracker, Thermal efficiency, condenser.

1. INTRODUCTION

The atmosphere of the earth absorbs some of the energy and the more air the sun's rays have to travel through to get to the earth's surface, the weaker they become. We can h harness the sun's energy to distil water. If there is a full sun, we can safely assume about 100 watts of solar rays per square foot. The key is developing technologies that efficiently convert solar power into usable energy in a cost-effective manner. One way to achieve this is by making a parabolic mirror. The purpose of the parabolic mirror is to collect the sun's energy over as wide an area as possible and focus it onto a smaller area. Solar powered water purification unit uses the process of distillation to purify the tap as well as contaminated water. Heat by the parabolic mirror at the focus evaporates the water and thus various salts and microorganism will remain left. Then the steam is passes through the condenser which converts the steam into water which is actually called the distilled water.

A portable distillation unit which can be setup anywhere in remote areas. All the material can be obtained from local market. Its main application is in remote areas where pure water is not available for drinking. It is used in various industries and chemical and biological laboratories where highly purified water is essential.

1.1 Water Distillation Principles

Every element can exist in three states: as a liquid, as a solid and as a vapor, which mostly depend on its temperature. This applies to water, too. So, water can be found as ice, water and steam. If water is cooled down below 0 degrees Celsius (32 Fahrenheit), it becomes ice, and if heated above 100 degrees Celsius (212 Fahrenheit), it becomes steam. The temperature, at which a substance changes it state from liquid to vapor is called a boiling point, and it is different for different substances. This difference can be used to separate substances, and as such can be used for water purification.

The process is relatively simple:

a) The dirty water is heated

b) To the boiling point and thus vaporizes

c) (Becomes steam), while other substances remain in solid state, in boiler. Steam is then directed into a cooler

d) Where it cools down and returns to liquid water

e) And the end result is a water, purified of additional substances found in it before distillation.

Distillation is an effective process and, what's more important, it can be done with a lot of improvisation. You can heat water with whatever is at hand: fire, electricity, or whatever. You can use almost anything that holds water for a boiler, as long as you can direct the steam into a cooler. A cooler can be a long piece of copper tubing bent into a spiral. All you need is something that will just cool the steam down. In a worst case scenario, you can distill water with an ordinary household pot and two pot lids. Boil water in a pot covered with the first lid. After a while, you'll see that the water in the pot vaporizes, and condenses on the lid (this is distilled water). Now replace the lid with the second lid, and turn the first one vertically, so that all condensed water collects at one point, and then pour it into a cup. Meanwhile, more distilled water condenses on the second pot lid, so just repeat the above steps again... until you have a full cup.

Distillation will remove from water almost anything, even heavy metals, poisons, bacteria and viruses. However, it does not remove substances that have boiling points at a lower temperature than water. Some of these substances are oils, petroleum, alcohol and similar substances, which in most cases don't mix with water. Also, remember that substances removed from water remain in the boiler, so you'll need to clean it up every once in a while. Distilled water can be used directly and does not need to be boiled again.

1.2 SOLAR WATER DISTILLATION

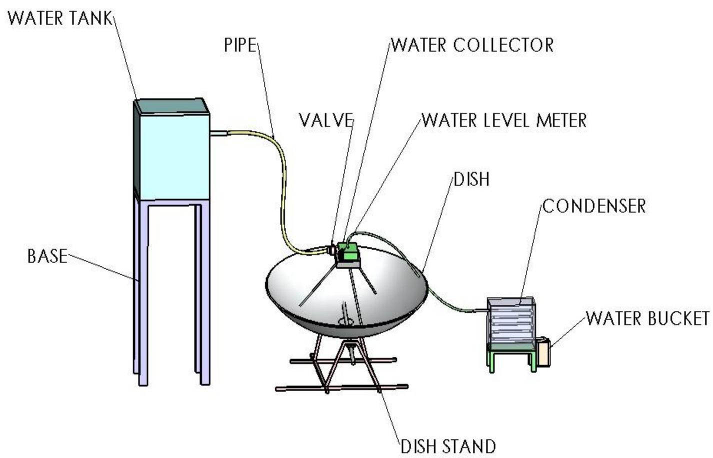
Solar water distillers or solar stills are usually used in remote areas where there is limited access to freshwater. The basic principles of solar water distillation are simple, yet effective, as distillation replicates the way nature makes rain. A solar still works on two scientific principles: evaporation and condensation. The salts and minerals do not evaporate with the water. For example, table salt does not turn into vapor until it gets to a temperature over 1400ºC. However, it still does take a certain amount of energy for water to turn into water vapor. While a certain amount of energy is needed to raise the temperature of a kilogram of water from 0ºC to 100ºC, it takes five and one-half times that much to change it from water at 100ºC to water vapor at 100ºC. Practically all this energy, however, is given back when the water vapor condenses.

The sea water is filled in the water tank and from this water tank the sea water will be go in to the copper collector by use of pu pipe collector will be held at the focal point of the parabolic connector disk. This water

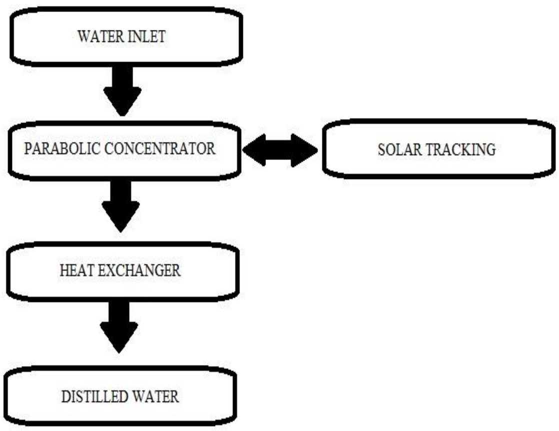
which collected in the collector are be heated by using of sun rays will be focus at point up to 100 C which is boiling point of water. And the boil water or steam will be go into the condenser by means of the pipe the condenser is water based condenser and the in condenser the copper pipe is used for good heat conductivity and the steam will be condense and the drinkable water is collected in the container.

2. PARTS AND MATERIAL USED

PARTS NAME	MATERIAL USED
WATER TANK	TIN SHEET BASED TANK
REFLECTOR	METAL SHEET CONCENTRATOR
COLLECTOR	COPPER
PIPE LINES	PU AND COPPER
BASE STRUCTURE	MILD STTEL
THERMOCOUPLE	K-TYPE{NICKEL-CHROMIUM }
HEAT EXCHANGER	COPPER PIPES AND WATER



3. DESIGN METHODOLOGY



4. CALCULATIONS

4.1) CONETRATIC DISK CALCULATION:-

- $D_a^2 = 16 (d) f$

  $f = \frac{(1.09)2}{16 * 0.165} = 0.45$ cm.

  Where, D_a = Aperture Diameter
  d = Depth of Disk
  f = Focal point distance.

- $A_a = \frac{\pi}{4}(D_a)^2 = \frac{\pi}{4} (1.09)^2 = 0.9331$ m².

where , A_a = Area of Aperture

- $A_c = L * L$ (because the surface of the collector is square in shape.)

$= L^2$
$= (0.1524)^2$
$= 0.02323\ m^2$.

The Concentric ratio: - Concentric ratio is between the areas of Aperture of the area of the collector.

- $C = \frac{Aa}{Ac} = \frac{0.9331}{0.02323} = 40.17$

The efficiency of most Solar Concentrator is 40% - 60%. (Mangal, 1993)

- $M_w = \frac{\eta\ id\ \pi\ Da2}{mcp\ (Tw - Ta)} = \frac{0.5 * 750 * \pi * (109)2}{1.5 * 4186\ (100 - 25)} = 10.699$ kg / hr.

  Where ,M_w = Rate of heating water
  i_d = Direct Radiation
  = 750 W/m^2 (Average radiation in March in Ahmedabad)
- $M_w = \frac{\rho w * Vw}{t}$

  $t = \frac{997.01 * 0.0015}{2.9722 * 10-3} = 503.1676$ s = 9 min.

4.2) CALCULATION FOR CONDENSER:-

- $Q = U\ A\ \Delta T$

Where, Q = Heat transfer rate.
U = Overall Heat Transfer Co – efficient.
A = Area of the tube.
ΔT = Temperature Difference.

- $A = n\ \pi\ d\ L$

  Where, n = No. of Tube passes.
  d = Diameter of the Tube.
  L = Length of the Tube.
- $\frac{1}{U} = \frac{1}{h1A1} + \frac{1}{k1A2} + \frac{1}{h2k2}$

  Where, h_1 = heat transfer C_o– efficient of water.
  h_2 = heat transfer C_o – efficient of steam.
  K1 = heat conductivity of copper tube.

- $\frac{1}{U} = \frac{1}{h1} + \frac{1}{k1} + \frac{1}{h2} = \frac{1}{50} + \frac{1}{385} + \frac{1}{250} = 0.02659$

  $U = 37.598\ W/m^2 k$.
  We are assuming that the heat transfer rate is in steady state condition.

- $Q = h\ A\ \Delta T$
  = 50 * 1 * (100 - 25)
  = 3750 W.
- $Q = U\ A\ \Delta T$
  3750 = 37.598 * 6 * π * 0.06 * L * 75
  L = 1.27 m ≈ 130 *cm*.

5. CONCLUSION

After completing the project, conclude that our project is simple in construction and compact in size for use. Manufacturing of machine is easy and cost of the machine is less.

A parabolic solar disc collector with solar tracking has been designed, built and tested.

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