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Designing of A Domestic Purpose Ground Water Desalination Plant Using Solar Energy

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Abstract

Renewable energy resources like tidal, geothermal, solar, wind, etc., play a vital role in our energy needs with the decline of fossil fuels. The efficient use of solar energy will be of primary importance to replace the conventional energy source in future. The present study details the utilization of solar energy for desalination of water for domestic purpose. It involves the designing of ground water desalination plant for small scale domestic purpose. Ground water is heated by solar radiation directly into the receiver and the generated steam is collected & condensed. Overall cost of this plant is kept low &also it is not harmful for the environment. This Solar based distillation system is optimum to remove minerals & hardness found in ground water and make it suitable for drinking. For a normal Indian family of 5 persons requiring 25 Liters of pure water per day under normal conditions the design conditions was calculated. With heat load of 3584 W, Area of Apreture was found to be 8.54m^2 and the area of one module was calculated as 1.31$m2^{\cdot}$ Total number of modules calculated was 8. The diameter of absorber was calculated as 0.0264Meters while the focal length of dish was calculated as 0.36 Meters. Economically it was found that with per day distilled water production of 5000 litres, the total savings are of Rs 12500 and a payback period of 6 Years was also calculated.

Keywords: Solar Energy, Desalination, Dish Collector, Flash Chamber, Absorber

Introduction: Energy is human beings and nature's primary and most universal kind of work. For the input to their bodies or computers, many people use the word power and speak of raw fuels and electricity. The key source of power can be solar energy. And also it could give the greatest potential is a small amount of it is usedIt is a resource that would become the main energy provider if the other energy sources were exhausted. Where sun hits atmosphere the solar power at that point is 1017 watts, where as the power reaching the earth surface is 1016 watts. The average demand for power in all society uses is 1013 watts. This solar energy can be used for many purposes such as heating, desalination, distillation and raising stem which further can be used to run prime movers.

Utilization of solar energy in India is of great importance since it lies in a temperature climate region of the world where sunlight is available in abundance for the major part of country throughout the year. In the village, long-distance travel is very common for people to collect drinking water. The abundant solar energy available at the site can be used to convert the available groundwater, which is salt, to desalinated water.

Fresh water is a necessity for the livelihood and the key to success. Culinary water sources become quickly unsatisfactory, both for domestic and agricultural applications and constantly developing industries, to meet the needs of an increasing population. In arid and semi-arid

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regions and some coastal zones, the problem with water is acute. The definition of salty or brackish water is any water with fewer dysfunctions than that of sea water.
Desalination means conversion of saline water into suitable form so that human can consume it.. But this separation needs energy. Solar energy is thermal energy in radiation form, so it can be used for water distillation.
Salty or brackish water distillation solves the diverse and innumerable water problems to some extent. Most existing plants use fossil fuels as an energy source. While few techniques such as multifaceted evaporation, flash evaporation of several stages and thin film distillation have been applied, the process is energizing and expensive. Hence, application of solar powered or solar augmented distils, can replace need for a large proportion of oil or other desalination plants.
W.R.Mccluney et al explain the basic principles of solar distillation of water and its economics over bottled drinking water purchased in the store. Also researcher discussed about details of purity of water by solar distillation method. After experimentation researcher found that purity of water is increased by slow distillation rather by rapid. Also Solar distillation of tap water or brackish ground water can be a pleasant and energy efficient option. [1]
The design of solar energy systems both thermal and photo voltaic types is illustrated by another author Bagget. He also discussed about the Solar Resource and the ability of various types of solar collectors to capture it effectively. Along with this design tools are developed which integrate performance of isolated solar collectors considering Economic and Environmental effects. [2]
Solar dish concentrators provide high temperature and efficiency. And solar thermal energy at a price comparable to residential satellite dish antennas. The assessment of this relationship results in an economic analysis and return on investments by using the refined production references for solar energy collectors. Researcher estimated cost of thermal output per kilowatt and found that annual efficiency could be better or worst depending on the site, dish opening temperatures and maintenance. Also solar steam is possible. [3]
For different climate conditions, plant capabilities, cost of solar collector and costs of a conventional energy supply, special cost of the product is evaluated. Researcher tried to explain the working of a direct solar distillation system and solar multi-effect distillation plant and multistage flash distillation plant. The economical benefit of solar direct steam generation from brine is pointed out as having better thermo dynamic efficiency. [4]
2 Solar energy based for domestic purpose water desalination: Solar desalination plants have proven to be efficient, quick, scalable, sustainable and affordable for the production of potable water from almost any locally required water. The ground water is pumped into the overhead tank and can then travel under a controlled flow rate through the absorber coil. The solar collector relies on the absorber spool with the power of the wind.

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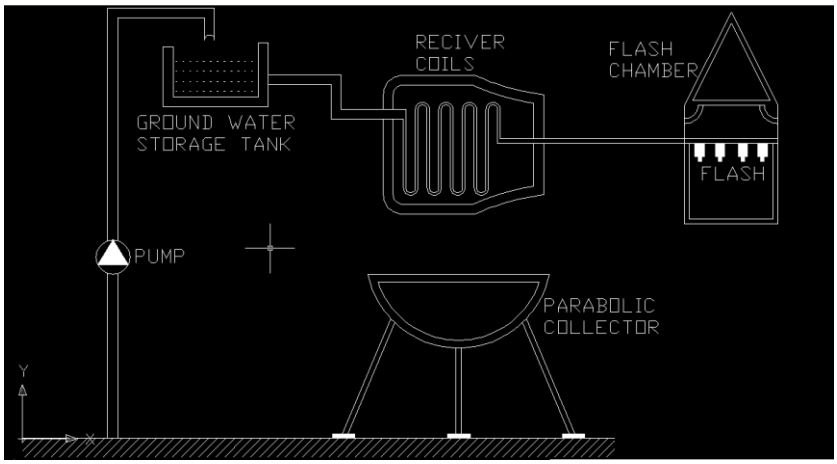

Figure 1: Domestic Purpose Water Desalination Method

The focused incident rays thus heats the absorber pipe and water gets heated up due to this. This will change heated water into steam. The steam is then made to pass through the pipe which is then collected into the flash chamber. The flash chamber made of mild steel with a pyramidal shape top made up of glass. The steam thus moves up and gets condensed. Water is then collected from the top of the flash chamber which can be used for drinking.

3 Theory of Design: The various factors that influence the design are as follows:

1. Performance factor
2. Structural factor
3. Environmental factor
4. Reliability factor
5. Cost factor

3.1 Performance Factor: The design of the equipment mainly depends on its performance requirement. It should be able to deliver the required performance

3.2 Structural Factor: The structure of the equipment should be such that it should be able to withstand the stress created. The material for the outer cover of the collector is chosen as G.I.Sheet because of its low cost, sturdiness and heat reflecting capacity. The receiver tank should be made of sufficient thickness, so that the failure does not occur due to the pressure created inside. Hence mild steel is used.

3.3 Environmental Factor: The equipment should be not polluting and should not pose any hazard to the surroundings. It should be capable of performing effectively under the required environmental conditions.

3.4 Reliability Factor: The equipment should have a long life and should be reliable. The maintenance costs have to be less.

3.5 Cost Factor: The design and selection of the materials should be such that the cost of the equipment comes within the economic limits of the people in the country.

4 Design Calculations:

Design of solar desalination plant using parabolic dish collector for a normal Indian family under normal environmental conditions is done and dimensions are calculated:

Family size = 5 members

Drinking water needed, (M) = 25 litres/day

Operating hours/day = 6 hours

Average beam radiation, HbRb = 700 W/ m^2

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Peak sunshine = 5 hours
Pressure = atmospheric
Enthalpy of dry steam at atmospheric pressure hg = 2706.3 KJ/kg
Enthalpy of water at 30 degree centigrade, hf = 125.79 KJ/kg
Collector efficiency (?ib) = 50%
Concentration ratio (Cr) = 20
1, Heat load, Q = M * (h_g- h_f) = [25 / (5*3600)] * [2706.3 – 125.79] = 3.584kw = 3584 W
Area of aperture, Aa = [Q / (?ib * HbRb)] = [3584 / (0.6*700)] = 8.54 m²

$$Aa = 4/3\pi r^2$$

Radius of aperture = 0.6 meter
Area of one module = πr^2 = Π (0.6)² = 1.31 m^2
Modules required = (Aa/A) = (8.54/ 1.31) = 8
2, Area of absorber/ receiver Ar = Aa/ Cr = 1.131/ 20 = 0.0566 m^2
0.0566 =Πd^2/4
0.0566 = 3.927 d^2
d = 0.0264 meters
3, Focal length of parabolic dish (f) = DXD/16d = 1.2X1.2/6X26= 0.36 meter
5 Economic Analysis: The estimated cost of a parabolic dish collectorused in homes for desalination process using solar energy is Rs 9430 (Approx.)
Equipment model for 8 modules = Rs 9430 x 8 modules = Rs 75440
Distilled water produced in a year = 25 litres/day x 200 days = 5000 litres/year
Savings in cost per annum = 5000 litres x Rs 2.5 / litre = Rs 12500
Simple payback period = total cost/ savings = Rs 75440/ 12500 = 6 years (approx.)
6, Conclusion: Present study details the utilization of solar energy for desalination of water for domestic purpose. It involves the designing of ground water desalination plant for small scale domestic purpose. For a normal Indian family of 5 persons requiring 25 Liters of pure water per day under normal conditions the design conditions was calculated. With heat load of 3584 W, Area of Apreture was found to be 8.54m^2 and the area of one module was calculated as 1.31m2. Total number of modules calculated was 8. The diameter of absorber was calculated as 0.0264Meters while the focal length of dish was calculated as 0.36 Meters. Economically it was found that with per day distilled water production of 5000 litres, the total savings are of Rs 12500 and a payback period of 6 Years was also calculated.

References:

1, W.R.Mccluney et al (1984),"Solar distillation of water", Copyright Florida Solar Energy Centre, University of Florida, FSEC-EN-380.
2, Baggett, el al (1992), "Solar energy system design", Desalination, vol.168, PP 235- 240.
3, Campbell, el al (1998), Copyright Florida Solar Energy Centre, University of Florida, FSEC-EN-290
4. Carlos Gomezcamacho, el al,(1999), "Preliminary design and cost analysis of solar distillation system" , Desalination, 126 (1999) 109-114.
5. Jaroslav vanek, el al, (1999), "A solar ammonia absorption icemaker". Home power 53.
6, G.D.Rai; solar energy utilization, khanna publication, 2003
7, B.S.Magal; solar power, Tata McGraw Hill, 2003
8, H.P.Garg, J.Prakash; solar energy fundamentals and applications, Tata McGraw Hill, 1997
9, H.P.Garag, T.C.Kandpal; Solar thermal Experiments, Noroser Publisher, 1999

ISSN: 0971-1260
Vol-22-NO-30 Special Issue- December-2019

10, S.P.Sukhatme, Solar Energy- Principle of Thermal Collection and Storage, Tata McGraw Hill,2000
11, Solar Energy System Design, Daggett, Et al, 1992, Desalination, vol.168
12, Solar Energy Return on Investment: Solar Dish Concentrator Performance, Campbell, Et al, September 1998