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Experimental study on material of compound parabolic concentrator to increase efficiency of solar evacuated tube for hard water desalination

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ABSTRACT

The use of solar energy in thermal desalination process is one of the most promising applications of renewable energies. In a solar desalination system, solar energy is utilized for heating salt water and converting it into soft water. A set of the evacuated tube and compound parabolic solar collector mainly get high-temperature performance in the range of 1200˚C-1250˚C. The annual yield is at its maximum when the condensing glass cover inclination is equal to the latitude of the place. The solar desalination system is eco-friendly and popular in rural areas. In the future, there is great scope in research carried out with other developed technologies such as ETC, ETC with heat pipes and multistage solar distillation.

Keywords— *Solar desalination, Evacuated tube, Compound parabolic concentrator, Material of compound parabolic concentration*

1. INTRODUCTION

1.1 Desalination

The avaibility of fresh water is becoming a very important issue in many areas of the world. In dry areas potable water is very scarce and the establishment of a human habitat in these areas strongly depends on how such water can be made available. Water is necessary to life. The importance of supplying potable water can hardly be overstressed. Water is available in plenty amount on earth, which covers three fourths of the planet's surface. The earth's surface is covered with 97% of salt water in the oceans and 3% with fresh water which is in the form of ice at the poles, ground water, lakes and rivers, which supply most of human and animal needs. Over 70% from this little 3% of the world's fresh water is frozen in glaciers, permanent snow cover, ice and permafrost. 30% of all fresh water is underground, most of it in deep, hard-to-reach aquifers. Lakes and rivers together contain a little more than 0.25% of all fresh water; lakes contain most of it. [1]

1.2 Solar desalination

It is a technique to desalinate water using solar energy. There are two basic methods of achieving desalination using this technique. Those are direct and indirect methods. Direct method includes providing heat to evaporative desalination from direct sunlight. On the other hand, the indirect method includes converting electricity to power a membrane process. [1] Desalination can be achieved by using various techniques. At industry level desalination is done by using either phase change or involve semi-permeable membranes to separate the solvent or some solutes. Thus, desalination techniques are classified into the following categories:

(a) Phase-change or thermal processes
(b) Membrane or single-phase processes

Before the processes start a chemical pre-treatment of raw Seawater is done to avoid scaling, foaming, corrosion, biological growth, fouling and also require a chemical post-treatment. [4]

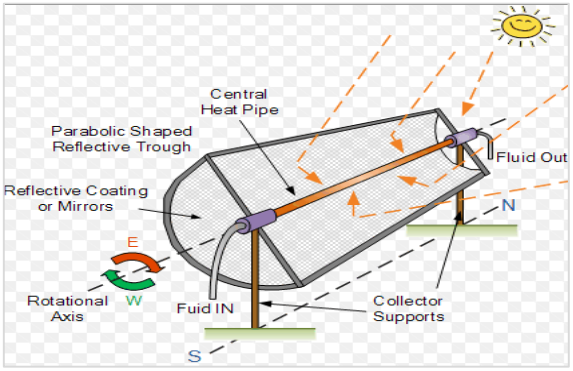

Fig. 1: Hybrid system of solar desalination [5]

2. LITERATURE REVIEW

Kalogirou S. mentioned a review of the various renewable energy desalination systems which are presented together with a review of a number of pilot systems erected in various parts of the world. The selection of the appropriate RES desalination technology depends on a number of factors. These include plant size, feed water salinity, remoteness, availability of grid electricity, technical infrastructure and the type and potential of the local renewable energy resource. Among the several possible combinations of desalination and renewable energy technologies, some seem to be more promising in terms of economic and technological feasibility than others. [1]

Gohane G. et al concluded that it is easy to manufacture and maintain the Compound parabolic concentrator. Thermo siphon process plays the most important role in the complete system. With the help of a solar tracking system, the maximum amount of solar energy can be concentrated. By using ETC in CPC 20% greater efficiency can be achieved than cylindrical parabolic concentrator. [2]

Kedar A. S. et al mentioned that energy is a basic necessity for all us to lead a normal life in the world. The use of solar desalination is one of the best application of renewable energy. A set of the evacuated tube and compound parabolic solar collector get high-temperature performance in the range of 1200˚C-1250˚C. The annual yield is maximum when the condensing glass cover inclination is at the same angle as that of the latitude angle of the place. The solar desalination system is nature-friendly and popular in rural areas. In future, there is great scope in research carried out with other developed technologies such as ETC, ETC with heat pipes and multistage solar distillation. [3]

3. WORKING COMPONENTS ARE AS FOLLOWS

3.1 Evacuated Tubes

Heat losses are minimized in ETCs by an evacuated cover of the receiver. This cover is tubular and made of glass. In addition, a selective coating of the receiver minimizes the losses due to infrared radiation. There are two different types of evacuated tubes: (1) Dewar tubes - two coaxial tubes made of glass, which are sealed each other at both ends; and (2) ETC with a metallic receiver, which requires glass to metal seal. There are different designs depending on the shape of the receiver. ETCs are set in combination with reflective surfaces. Evacuated tube collector maintains the temperature in the range of 800˚C to 900˚C. [2]

3.2 Copper Tube

It is the simplest form of a tube which is made up of copper with dull black color so the maximum amount of solar energy can be absorbed. [2]

3.3 Compound Parabolic Concentrator

Maximum collection and utilization of solar energy are achieved in the parabolic collector and it can be achieved in a short period of time. The shape of solar concentrator is normally taken in the form of a parabola. The temperature attained is in the range of 250˚C. [3]

3.4 Condenser

A water-cooled condenser is a heat exchanger that removes heat from water vapor and transfers to the cold water around it. In doing so, the vapor condenses and pure water is obtained.

4. WORKING PRINCIPLE

The working of a focusing solar concentrator is to reflect solar radiation to a small area, where the receiver is located as shown in figure 2 to collect the maximum amount of sun rays on to the receiver. The parabolic concentrator should be constantly in line with the sun rays. The receiver must be of dark black color to absorb maximum solar radiation so that the solar energy is transformed into heat energy.

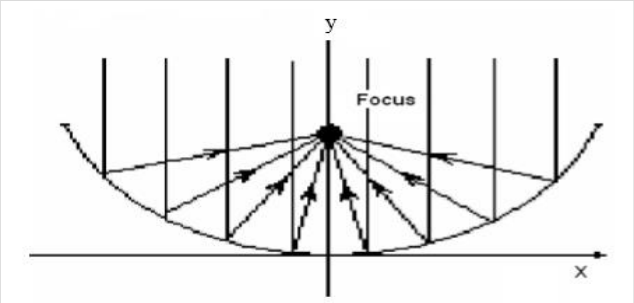

Fig. 2: Working Principle of compound parabolic concentrator [6]

5. EXPERIMENTATION PROCEDURE

(a) To study and determination of characterization of hard water.
(b) To study the theory of various temperatures, solar intensity, time and wind velocity for the required days.
(c) Study of various different contaminants present in the water. Chemical composition of an initial and final water sample analyzed and compared the Indian drinking water specifications IS-10500:2012
(d) Solar Desalination either can directly use solar energy to produce distillate directly in the solar collector, or indirect combining conventional desalination techniques, such as Multistage Flash Desalination (MSF), Vapor Compression (VC), Reverse Osmosis (RO), Membrane Distillation (MD) and electro dialysis, with solar collectors for heat generation.
(e) Direct solar desalination compared with indirect technologies requires large land areas and has relatively low productivity.
(f) Desalination of the contaminated water can help countries meet the rising demand for potable water. Desalination means the removal of salt and other minerals from contaminated water to make it fit for the drinking and industrial application.
(g) Instantaneous energy efficiency to find out using (ETC+CPC) [3]

6. MATERIAL SELECTION

Materials are selected by using the following properties
(a) Physical properties like tensile strength, density.
(b) Optical properties like reflectivity, transmitivity, absorptivity.
(c) Environmental properties like corrosion resistant, degradation of material due to ultra violet radiations, moisture penetration etc.

Table 1: Studied Reflective Material of CPC and its properties

Material	Reflectivity	Trasnmitivity	Absorptivity	Corrosion Resistance
Mirror coating	99%	0.02	0.08	High
CVANU	95%	0.03	0.02	Low
Polished Anodized AL	95%	0.04	0.06	Very High
Maylar	98%	0.015	0.03	High
White flat paint	90%	0.03	0.07	High

6. DIMENSIONS OF COMPOUND PARABOLIC CONCENTRATOR

Acceptance angle=40.4103º
Concentration Ratio=1.5426
Width of aperture at exit=182.2124 mm
Width of aperture at entry =281.08 mm
Height of concentrator =272.08 mm
Area of concentrator =1.2864 m^2
Area of absorber =0.3279 m^2
Length of CPC = 1800mm

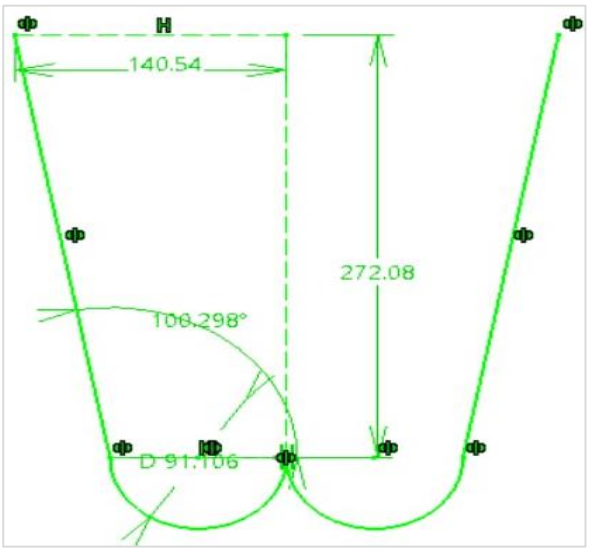

Fig. 3: Catia drafting of CPC [7]

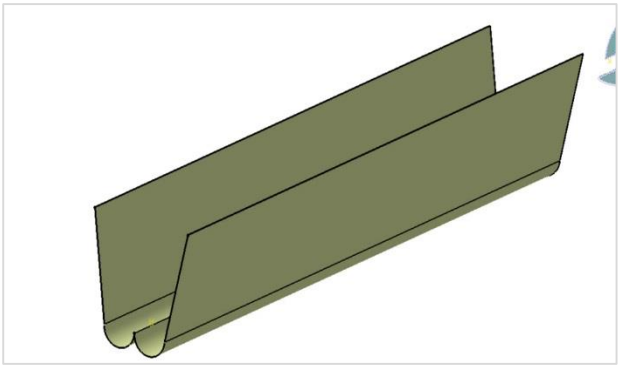

Fig. 4: Catia model of CPC

7. DIMENSIONS OF CPC STAND

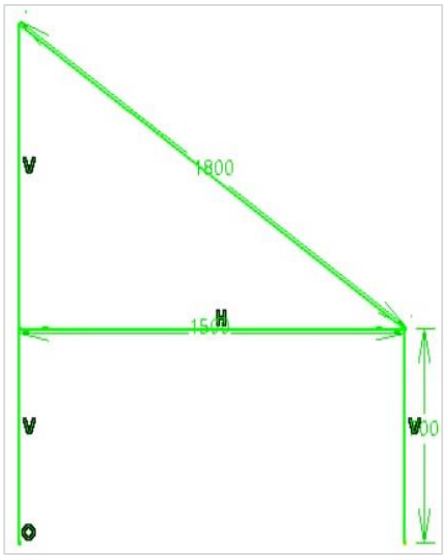

Fig. 5: Catia drafting of CPC stand

8. DIMENSIONS OF ETC STANDS

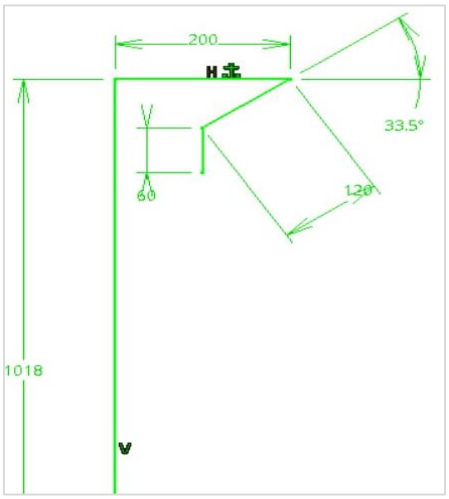

Fig. 6: Catia drafting of ETC stand (right side)

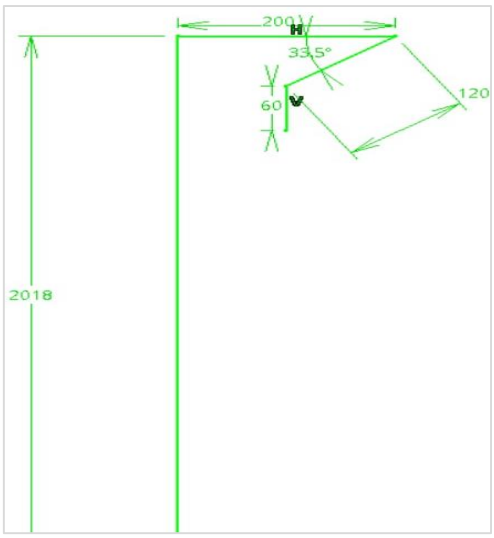

Fig. 7: Catia drafting of ETC stand (left side)

9. CONCLUSION

- To obtain soft water from hard water by using solar energy.
- To obtain the objectives following two materials are selected by considering different properties and different factors
- Maylar 2. CVANU (Chrome Mirror Silver Vinyl)

10. REFERENCES

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