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Design and Fabrication of Solar Parabolic Collector for Water Distillation

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Abstract

From geographic data around the planet is covered around 70% with water, but out of total, only around 2% is of fresh water, and out of total fresh water, about 1.6% is not used because it is located in polar ice caps and glaciers. So total of the earth's water, 98% is saltwater, 1.6% is in polar ice caps and glaciers, and 0.4% is drinkable water, which is available from underground wells or rivers. The survey shows that around 1 billion people, or 14.7% of the total earth's population, still do not have pure safe drinkable water. So here an effort is made to design a water distillation system with use of the solar parabolic trough that can purify water from any source of water and convert it in to drinkable form. A solar parabolic trough collector is used to convert water into steam and later condense the steam to get pure water.

Keywords—solar energy, water distillation, parabolic trough collector

Nomenclature

Θ	Angle of incidence
δ	Declination
w	Hour Angle
Θz	Zenith angle
Aa	Area of aperture
Ar	Area of receiver

1 Introduction about solar parabolic trough collector

Solar energy has the highest potential of renewable energy available compared to all other sources of renewable energy. The magnitude of solar power where sun hits atmosphere is 1000 times more power than what is required. If we can use 5% of this energy, still it will be 50 times more than what the world will require. The energy, radiated by the sun on a normal bright sunny day, is around 4 to 7

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kWh per m^2. To use this energy a solar parabolic trough collector is made. It uses mirrors placed in parabolic cylinder shape, which reflects and concentrates sun radiation towards a receiver tube, which is located at the focal line of the parabolic cylinder. The receiver absorbs the radiations coming from mirror surface and convert it into thermal energy, which is latter collected by a fluid medium, circulating within the receiver tube. This method of concentrated solar collection through parabolic trough collector has the advantage of very high efficiency and low cost. The same concept can also be used either for thermal energy collection, for generating electricity or for both, therefore it is an important way to use solar energy directly.

2 Design of parabolic trough

2.1 Selection of Collector

Different types of solar collectors used for generation of steam are: (i) Parabolic trough collector (PTC), (ii) Compound parabolic collector (CPC) (iii) Flat plate collector (FPC).

Concentrating type of collectors possess some definite advantages as compared with the orthodox flat plate type of collectors:

- The temperature attained by working fluid is more in a concentrator system as compared with flat plate system collectors.
- The thermal efficiency is higher for concentrator system because of less heat loss area compared to the receiver area.
- Simpler in construction and therefore the cost of the system per unit area of the solar surface is reduced.

PTCs are generally of medium concentration ratio i.e. 15-40 whereas CPCs are generally of low concentration ratios i.e. 1.5-5.

2.2 Construction of Parabolic Trough

The sheet of a trough is made up of G.I. sheet and for more reflectivity, it is covered with aluminum foil on it. The pipe of aluminum is painted black to absorb more heat. The pipe is mounted on focal line by means of wooden stand.

2.3 Trough geometry

The geometry of the trough decides the amount of solar radiation absorbed by fluid, which acts as our aperture for solar collection. This can be calculated by the concentration ratio C = Aa / Ar

The aperture area is directly proportional to the concentration ratio, which indicates that the higher the concentration ratio, the higher the temperatures that can be reached. This is because the number of images, formed by the reflection of sunlight and seen by the receiver pipe will increase. However, the aim of the given project is to heat water and convert it into water vapor, and not to produce high quality steam; therefore, the system has medium concentration ratio i.e. about 10.

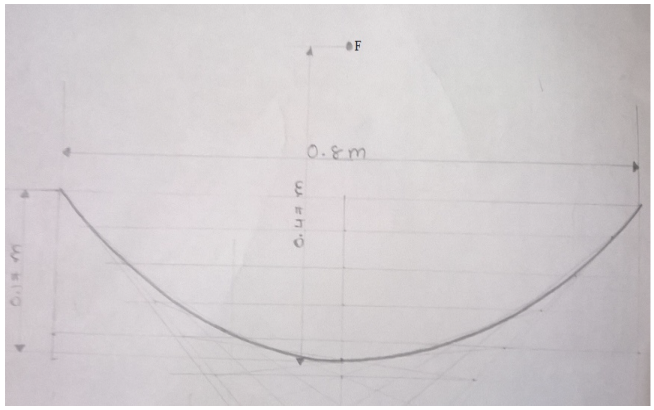

Figure 1 Geometry of Trough Collector

The trough selected for analysis is having following considerations:

Aperture 0.8 m
Focal length 0.47 m
Depth 0.17 m
Trough length 2 m
Aaperture 1.6 m^2
Areceiver 0.1571 m^2
Concentration Ratio 10.18

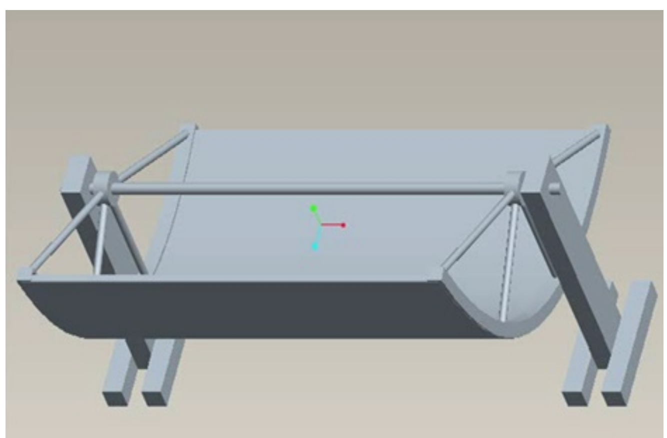

Figure 2 CAD Model of Trough Collector

Figure 3 Experimental set up of Trough Collector

3 Observations and Performance parameters

3.1 Optical Performance of Receiver

Optical performance of solar collector shows the magnitude of energy that is absorbed by receiver pipe compared to the energy received by the collector. Thus the aim here is to increase the optical performance of the system or receiver.

Angle of Incidence: $\cos\theta = (\cos2\theta z+\cos2\delta*\sin2w)^{1/2}$

Zenith angle : $\cos\theta z = \cos\varphi*\cos\delta*\cos w+\sin\varphi*\sin\delta$

Declination : $\delta=23.45*\sin(360*(284+n)/365)$

For n = 274 (Date:1st September)

We got δ = - 4.2155°

Angle of latitude for Anand = 22.5560 °

Hour angle	Angle of incidence	Zenith angle
-90	3.892	91.6158
-75	9.6077	77.8675
-60	15.0209	64.3875
-45	19.7795	51.4611
-30	23.528	39.6491
-15	25.9392	30.52386
0	26.7728	26.7728
15	25.9392	30.52386
30	23.528	39.6491
45	19.7795	51.4611
60	15.0209	64.3875
75	9.6077	77.8675
90	3.892	91.6158

Table 1 Observation Table

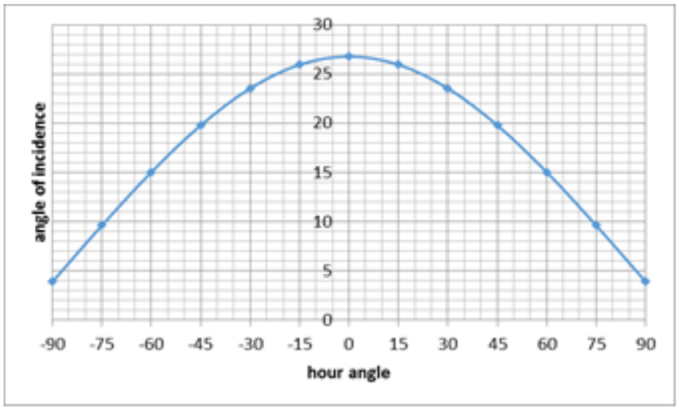

Figure 4 Variation of angle of incidence with hour angle

3.2 Observations

Day I (South Facing)

Initial temperature of water 23 ^{0}C
Duration for temperature measurement 30 min

Time	Final Temperature of water (^{0}C)
10 a.m.	28
11 a.m.	33
12 p.m.	41
1 p.m.	48
2 p.m.	43
3 p.m.	39

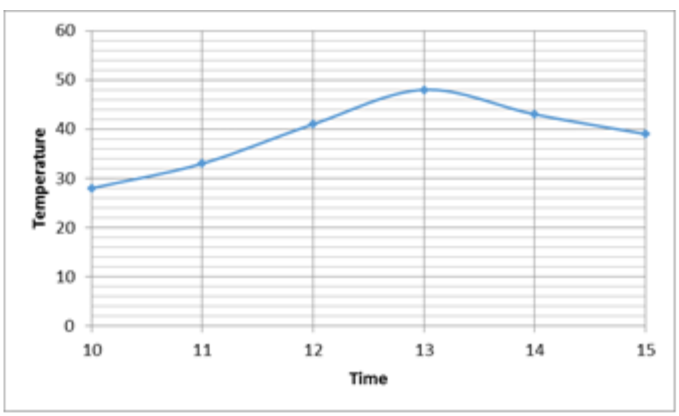

Figure 5 Variation of temperature with time for Day I

Day II (South Facing)

Initial temperature of water 23 ^{0}C
Duration for temperature measurement 40 min

Time	**Final Temperature of water (^{0}C)**
10 a.m.	30
11 a.m.	35
12 p.m.	44
1 p.m.	57
2 p.m.	50
3 p.m.	45

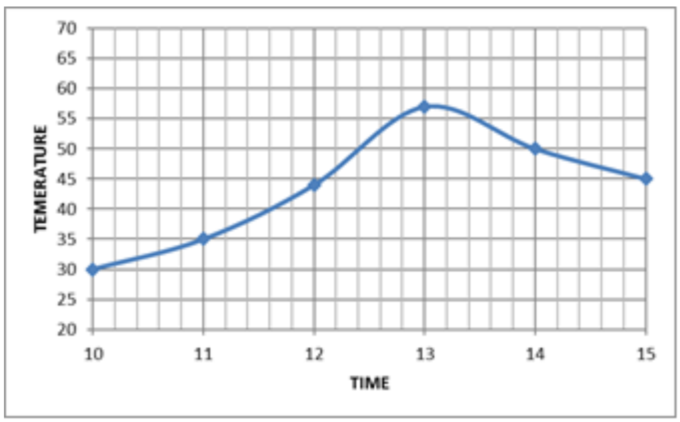

Figure 6 Variation of temperature with time for Day II

Day III (South Facing)

Initial temperature of water 23 ^{0}C
Duration for temperature measurement 50 min

Time	**Final Temperature of water (^{0}C)**
10 a.m.	32
11 a.m.	38
12 p.m.	47
1 p.m.	63
2 p.m.	54
3 p.m.	47

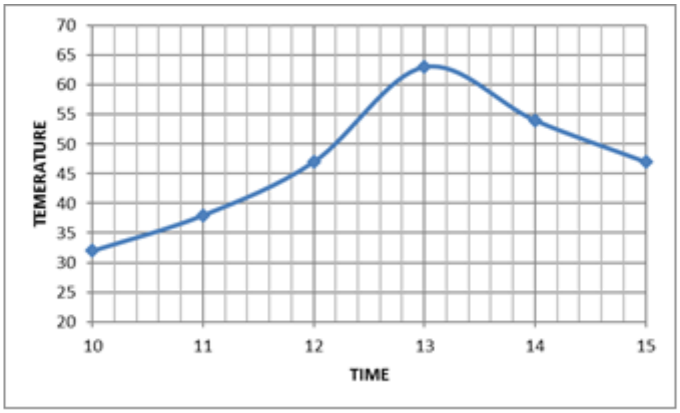

Figure 7 Variation of temperature with time for Day III

Temperature of water in time duration at 1 p.m. by tilting parabolic trough at hour angle

Time duration	**Temperature (^0C)**
30 min	52
40 min	61
50 min	68

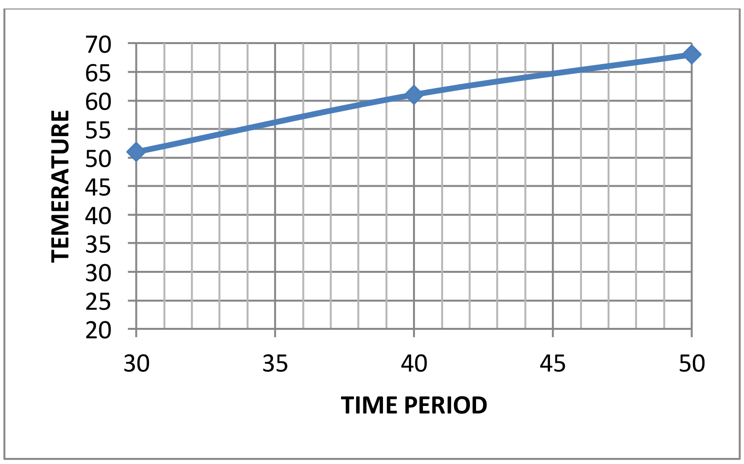

Figure 8 Variation of temperature with time at hour angle

4 Material cost in Indian rupees

Sr. No	Materials	Qty	Cost
1	Wood	1	Nil (work shop)
2	M.S. sheet	1	650
3	G.I. pipe	1	150
4	Aluminium foil	1	70
	Total		**870**

Table 2 Observation Table

5 Conclusion

From references, it was decided to get steam from water through parabolic collector and converted it into distilled water but we did not get steam because of following reasons:

- Manufacturing defects:

  There may be some error in construction of parabolic shape
  There may be deflection of pipe from focal line by weight of the parabolic trough

- There may be less intensity of solar radiation due to winter season so we couldn't get required output.

- Time duration considered in solar still may be less by this reason we couldn't get high temperature

➢ Angle of incidence will be maximum when the trough is inclined at hour angle

➢ Maximum temperature attained will be more when trough is inclined at hour angle compared to simple south direction as shown in Table 3.

Time period at 1 p.m.	Temperature in ^{0}C when trough south facing	Temperature in ^{0}C when trough tilt at hour angle	Diff. In temp. ^{0}C
30 min	48	52	4
40 min	57	61	4
50 min	63	68	5

References

Scrivani, El Asmar, and Bardi, (Feb. 2007): *Solar trough concentration for fresh water production and waste water treatment, Desalination, Elseveir, ,Volume 206, Issues 1–3, 5 February 2007*, (pp. 485–493).

Brooks, Mills, Harms. (August 2006*): Performance of a parabolic trough solar collector, Journal of Energy in Southern Africa, Volume 17* No. 3.

Gang Xiao. (2007): *Manual making of a parabolic solar collector*, Internet archieve

Andrew, Joel and Mark.: *Parabolic Solar Water Distillation, Project, SDSU College of Engineering*