Research of Assorted Parabolic Reflectors

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Abstract- **In ever growing field of renewable energy, it is no surprise that solar energy plays a pivotal role in harnessing free energy for tremendously growing needs. Experimental setup has been designed to test and compare the efficiency of different parabolic solar reflectors made of Stainless steel and Mirror. The goal of research is to get maximum temperature output comparing the Stainless steel and Mirror Parabolic reflectors for circulated water flow.**

Index Terms- Parabolic reflector- stainless steel &mirror, zenith angle, incident radiation, direct radiation.

INTRODUCTION

A parabolic trough solar collector uses a mirror or mirror finished material in the shape of a parabolic trough to reflect and concentrate sun radiations to a receiver tube located at the focus line. The receiver absorbs the incoming radiation and transform into thermal energy which is carried by fluid medium circulating within the tube [1]. The temperature of delivery tube depends on the area of parabolic trough and length of the setup.

Fig1. Parabolic trough collector

The collectors are considered based up on the temperatures such as heating, thermal energy generation, refrigeration, and desalination, etc. In last decades various designs have been implemented and tested for concentrating solar energy. The design of the Concentrators is reflection or refraction, sometime is cylindrical or flat, and can be continuous. The Collector can be flat, concave or convex and can be covered or uncovered [2].

Solar reflectors can be classified as follows:

- Parabolic Trough (Fig.2, a)
- Dish Concentrators (Fig.2, b)
- Solar Towers (Fig.2, c) and
- Flat plate collectors (Fig.2, d)

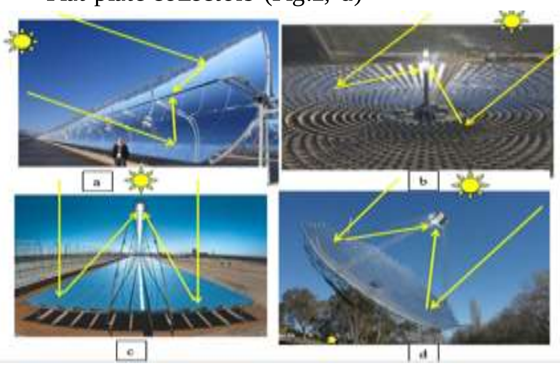

Fig.2 Types of concentrators:

II DESIGN

The Parabolic frame is made up of plywood. It is to be attached to a base which allows for angling or Tracking of the parabolic trough as per sun Direction.

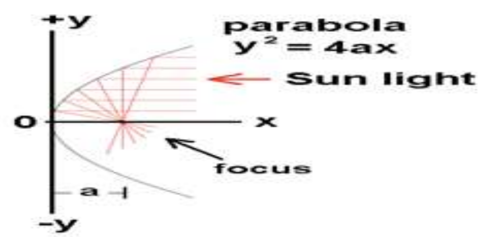

Fig3. path of parallel rays at a parabola

The receiver used is 6mm diameter copper pipe as it has high thermal conductivity and it is inexpensive. The water source is taken from reservoir located above the trough, the flow is due to gravity. For testing, a simple flow regulator was used between the tank and copper pipe to regulate the flow. This is easier and more efficient, as well as significantly less expensive.

Fig 4. Stainless steel sheet of grade 304.

Glass mirrors has high reflectance (91% at 8 m rad full-acceptance angle), long lifetimes, durability in field and degradation of reflectivity over the concentrator lifetime. Reflection of light is an inherent and important fundamental property of mirrors.

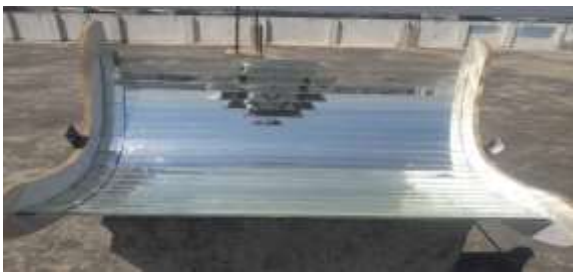

Fig 5. Mirror parabolic trough.

The next step consists of drawing of parabolic shape on the plywood, followed by a slot for sheet to be inserted. Then the strips were cut into the proper lengths using the hack saw. Finally, parabolic frame of plywood was assembled and sanded to achieve the parabolic curve. A hole was drilled in each plywood pieces to attach L-plate, with help of this setup was attachment to the base [3]. To attach the stainless-steel sheet to the frame, the slot it was cut into shape by which the sheet is inserted into the frame. Holes were drilled in strip so that the copper pipe can be inserted and kept at focus point which is attached to plywood frame. Next the SS sheet was bent down into the parabola with help of bending machine and attached to frame.

Fig 8. Sheet inserted into frame

Finally, a T-joint was fitted to the copper pipe at the outlet for placement of thermometer. The setup was brought to the test site, and using the bolts, nuts, washers the trough was attached to base [4]

Fig 9. Copper pipe placed at focus.

III CALCULATIONS

Solar constant:

The intensity of solar radiation on a surface normal to the sun's rays beyond the earth's atmosphere at the mean earth-sun distance is defined as the solar constant I_{sc}.

The value of $I_{sc}$is 1353$\frac{w}{m2}$.

Because the earth orbit is slightly elliptical, and the extra-terrestrial radiation intensity I_o varies inversely as the square of the earth-sun distance.

Extra-terrestrial radiation intensity (Io) ranges from a maximum of 1398$\frac{w}{m2}$ on January 3, when the earth is closer to the sun.

To a minimum of 1310$\frac{w}{m2}$ on July 6, when the earth-sun distance reaches its maximum.

- Geographical location of Hyderabad is between 17.3850°N Latitude and 78.4867°E Longitude.
- Hyderabad land area (A) = 650km2.

Hence, Hyderabad would receive radiation at that rate:

Let R_c= extra-terrestrial radiation;

A = continental land area = 650km2;

I_{sc} = extraterrestrial solar constant;

Therefore

$$R_c = I_{sc} \times A$$

$$=1353\times 650 \times 10^6$$

$$= 87945\times 10^8 \frac{w}{m^2}$$

Therefore, for a yearly average sunshine hour of 9hours/day= 87945x10^8 × (366x9)

$$= 28969083\times 10^9 \frac{wh}{year}$$

Assuming a clearness index of 50% since 47% of extra-terrestrial radiation reaches the earth surface.

Terrestrial radiation in Hyderabad's land area:

$$=\{(\frac{50}{100}) \times 28969083 \times 10^9\}$$

$$=144845415\times 10^8 \frac{wh}{year}$$

The solar zenith angle is the angle between the zenith and the centre of the Sun's disc.

Where **Z**– Zenith angle

$\boldsymbol{\gamma}$ – Latitude of location

$\boldsymbol{\delta}$ – Declination angle

t– Hour angle

Cos Z = $\sin\gamma\ \sin\delta\ +\ \cos\gamma\ \cos\delta\ \cos t$

$= \sin 17.3850°\ \sin 23.45° +$

$\cos 17.3850°\ \cos 23.45°$

$= \cos 0°$ = 0.1231

Z = $\cos^{-1}(0.1231)$ = 86°.68′

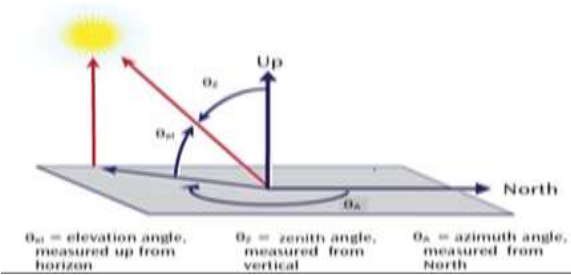

Fig 10. Zenith angle

S and C are climate graphically determined constants. The intensity of the solar radiation through the atmosphere is calculated thus:

$I_Z = I_{sc} e^{-c(\sec z)s}$

$= 1353 \times e^{-0.357(\sec 86.68)0.678}$

= 20.708w/m2

IV EXPERIMENTAL RESULTS

The Experiment was done on the parabolic trough for 28days. The whole set was placed in an open space in the sun and valves were taken from 7:00am in the morning to 5:00 pm in the evening each day. Resistance thermometer placed at the focal points, inlet and outlet was used to obtain its inlet and outlet temperature readings for constant flow of water for both parabolic troughs.

Where T_i – Average initial temperature of the water at inlet;

T_o – Average final temperature of water at outlet;

ΔT – Average temperature difference of T_i *and* T_o.

Table 1: average of day from 7am to 5pm of first week calculation

Sl. no	Stainless steel			Mirror		
	T_i	T_o	ΔT	T_i	T_o	ΔT
1	29.15	78.67	49.52	29	65.41	36.41
2	30.23	73.2	42.9	28.5	63.56	35.06
3	29.1	85.4	56.30	29.64	64.20	34.56
4	29.58	82.40	52.80	30.12	65.31	35.19
5	28.71	82.82	54.10	29.52	65.35	35.83
6	29.02	79.7	50.68	26.42	61.667	35.24
7	29.5	78.5	49	29.09	62.97	33.88

Table 2: average of day from 7am to 5pm of second week calculation

S. no	Stainless steel			Mirror		
	Ti	To	ΔT	Ti	To	ΔT
1	26.69	80.6	53.91	29.15	65.55	36.4
2	30.28	82.08	51.74	31.11	66.35	35.04
3	29.2	86.42	57.22	29.64	64.19	34.55
4	29.67	86.11	56.44	29.09	64.99	35.09
5	28.11	84.47	55.76	30.12	71.55	41.43
6	29.09	84.38	55.29	29.61	64.81	35.20
7	29.55	78.51	48.96	29.64	64.20	34.56

Table 3: average of day from 7am to 5pm of third week calculation

S. no	Stainless steel			Mirror		
	Ti	To	ΔT	Ti	To	ΔT
1	29.55	84.99	55.44	29.16	64.4	35.24
2	29.09	82.75	53.66	29.18	68.06	38.88
3	28.71	82.00	53.29	30.2	66.61	36.41
4	29.17	78.92	49.75	31.46	66.52	35.06
5	29.19	78.18	48.99	30.04	65.83	35.79
6	30.23	73.62	43.39	29.82	64.45	34.63
7	29.98	77.58	47.60	29.61	64.85	35.24

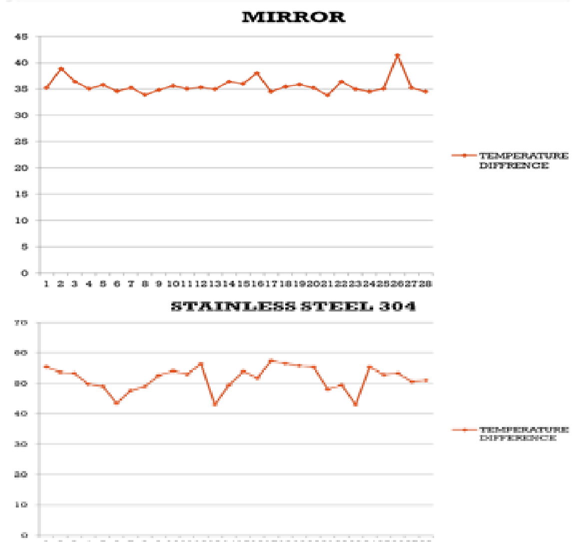

Fig11.Graphs comparison of both materials

V.CONCLUSION

In experiment with parabolic reflectors of the order of 610 x710 dimensions. Attempts were made to analyse the performance of the parabolic reflectors. The parameters chosen were that of the material used for making the reflective surface of the parabola. Having used glass strips and SS sheet with high buffing finish we were able to get average temperature data for the major part of the day for about 21 days.

However, it could observe that for glass strip parabola there seems to be a constant temperature despite the varying magnitudes of suns radiation but less temperature. This phenomenon was observed due to the pack of the parabolic profile while using straight strips.

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