Design of Concentric Solar Collector for Power Generation

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Abstract— **Solarenergy is the primary source of energy for our planet. Increased utilization of solar energy in our country would result in all around benefits, both in terms of cleaner environment and monetary gain. The energy from the sun is used for various purposes mainly as power generation known as solar electricity generation system and industrial process heat applications. The energy consumption in residential sector is substantial as it accounts for approximately one-third of overall delivered-energy use and carbon dioxide emissions of this In our country use of solar trough is mainly for power generation, industrial process heat applications, and for this applications development of a commercial industry to produce and market these solar trough systems but now it's time to come use of solar trough for domestic applications and manufactured it by using locally available material. In the present work, new parabolic trough collector system with manual tracking system which has been developed for hot water generation, Fabrication and design of a solar parabolic trough is done using locally available materials. In this project, we deal with the study of various collectors used for extracting solar energy, and optimization of collector to maximize the efficiency of the solar based power generation. The high intensity solar energy can then utilized for various domestic as well as industrial application.**

Index Terms— **PTSC, Optimizationetc**

I. INTRODUCTION

Solar energy is the primary source of energy for our planet. Increased utilization of solar energy in our country would result in all around benefits, both in terms of cleaner environment and monetary gain. The energy from the sun is used for various purposes mainly as power generation known as solar electricity generation system and industrial process heat applications. The energy consumption in residential sector is substantial as it accounts for approximately one-third of overall delivered-energy use and carbon dioxide emissions of this delivered-energy use, approximately a quarter is for water heating. Water heating is generally provided by burning non-commercial fuels, namely-firewood as in rural areas and for this application rural peoples are cutting trees to partial fulfillment of their daily energy requirements, this creates depletion of forests and thus it effect on climate change and commercial fuels such as kerosene oil, liquefied petroleum gas (LPG), coal; through either their direct combustion or through the use of electricity in urban areas, this uses of fossil fuels create air pollution and as the costs of natural resource depletion. In our country use of solar trough is mainly for power generation, industrial process heat applications, and for this applications development of a commercial industry to produce and market these solar trough systems but now it's time to come use of solar trough for domestic applications and manufactured it by using locally available material. In the present work, new parabolic trough collector system with manual tracking system which has been developed for hot water generation, Fabrication and design of a solar parabolic trough is done using locally available materials. In this project, we deal with the study of various collectors used for extracting solar energy, and optimization of collector to maximize the efficiency of the solar based power generation. The high intensity solar energy can then utilized for various domestic as well as industrial application

II.PRINCIPLE OF WORKING

The initial plan for a solar concentrator was to use a semi-spherical surface covered with many small sections of mirror to form a segmented, spherical concentrator. Referring to the optics section of a University Physics textbook it was found that the focal point of a spherical mirror would be located at a distance of half of the radius of the spherical section, directly above the vertex of the sphere. Quite some time was spent on trying to find a way to orient the small mirror sections at the proper angles about the inner surface of the sphere. The initial thought was to take the derivative of a circular equation to find the proper incline at different points along the

Sphere's inner surface. These inclines would then be rotated about the origin. This was a difficult problem considering the limited resources. After conducting more research on solar energy and solar collection, the decision was made to attempt to build a parabolic trough solar concentrator. In a parabola all of the incoming rays from a light source (in this case the sun) are reflected back to the focal point of the parabola. If the said parabola is extended along an axis (becoming a trough) the solar rays are concentrated along a line through the focal point of the trough. The focal point of a parabola is located at 1/4a, if the equation of the parabola is y = ax2 (Young, 1157).6 the parabolic trough selected fit the equation y = .04167x2 from x = -12 inches to x = 12 inches. This equation was chosen to yield a focal point located at 6 inches above the vertex of the parabola, for ease of construction. The frame for the parabola was made out of mild steel. It would be attached to a base which would allow for proper angling of the parabolic trough. The entire collector was small enough to allow for easy manual adjustment for solar tracking. The receiver chosen was a simple, half-inch copper pipe, painted black to absorb more incident radiation. Copper was chosen because of its high thermal conductivity and it is relatively inexpensive. The water source was planned as a reservoir located above the trough, with gravity assisted flow through the trough, to another reservoir used for collection of the heated water. These were going to be fifty gallon drums. A pieces of mirror glass is are stick on to the interior surface of trough

III. DESIGN

Parabolic tough collector
Let us assume parameter
Y= y axis distance
X= x axis distance
Equation of parabola is
$Y = \frac{x^2}{4(F)}$ .... (ref. solar energy book)
But $F = \frac{D}{4}$.......... [2]
Therefore $Y = \frac{x^2}{(D)}$
Calculations:-
Given:-
D=600mm=0.6m
F=150mm=0.15m

For the various values of 'X' we find the value for 'Y'

Table No 1 Values of X and Y

X(mm)	Y(mm)	X(mm)	Y(mm)
0	0	250	104.16667
10	00.166	300	150
50	04.1667	350	204.166
100	16.67	400	266.666
150	37.5	450	337.5
200	66.66	500	416.667
220	80.66	550	504.1

We plot the graph of parabola
Now we have to calculate width of parabola (s)= distance between X1and X2
So, let us consider
P = horizontally measured distance between origin to X2
P = 300mm=0.3m
t = vertical measured distance between origin to focal point
t = 150mm=0.15m
t = 2F =2*0.15mm
$q = \sqrt{t^2 + p^2}$

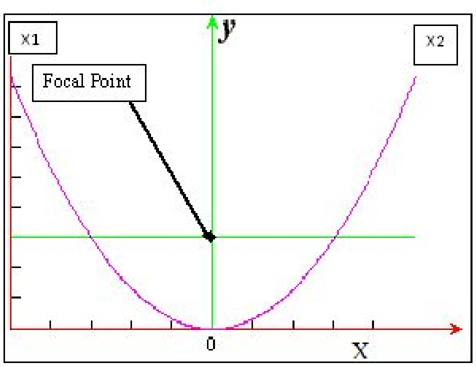

Fig.1.Geometric representation of designed collector

$q = \sqrt{0.3^2 + 0.3^2}$

q =0.4242m

So, Width of parabola = $\{\frac{p*q}{t} + t * \ln \frac{p+q}{t}\}$
Width of parabola = $\{\frac{0.3*0.4242}{0.3} + 0.3 * \ln \frac{0.3+0.4242}{0.3}\}$

Width of parabola = .6883m

For length,
We are assume the length is 7*of focal length ……(ref. paper 2)
Therefore L=7*F
L=7*0.15

L=1.05m

Aperture area =S*L
= 0.6883*1.0.

Aperture area = 0.72271m^2

Now we have to calculate 'RIM angle (ψ)
RIM angle (ψ) = $\frac{\theta}{2}$
We know that Arc Length = R*θ
Width of collector = R*θ
Therefore R*θ =0.6883
R = radius =0.3m
Therefore 0.3*θ =0.6883
$\theta = \frac{0.6883}{0.3}$

$\theta = 131.7^0$

RIM angle (ψ) = $\frac{131.7}{2}$

RIM angle (ψ) =65.71^0

The absorber has to be constructed in such a way that high radiation absorption and low thermal losses are realized. Low thermal losses refer to low radiative losses as well as low convective and conductive losses. In the following we will describe how and with which components the receiver fulfils these functional requirements. So we have selected the copper pipe absorber tube

- Various losses in absorber tube

1.Optical losses

Optical losses are produced at the glass tube as well as at the absorber tube. The glass tube has only a limited transmittance so that a part of the radiation is reflected and another part is absorbed. As already mentioned, antireflective coatings and highly transparent glass materials reduce the loss to around 4%. The absorber tube has only a limited absorptance so that another part of the incomingradiation is reflected at the absorber tube. Selective coatings reduce this loss to around 5%. The foregoing equation relates the losses to the active receiver surface area and not to the total receiver surface area. This is the case because an additional optical loss has to be taken into account: The bellows and metal shields at the ends of the receiver reduce the active receiver area by nearly 4% (Siemens indicates 3.6%).

3. Thermal losses

Thermal losses are generated by thermal radiation, convection and heat conduction. Heat conduction and convection between the hot absorber tube and the cooler glass tube are reduced considerably by the vacuum. Heat conduction can be neglected and will not be mentioned here.The thermal losses of a receiver depend strongly on the temperature difference between the absorber tube and the surrounding air.

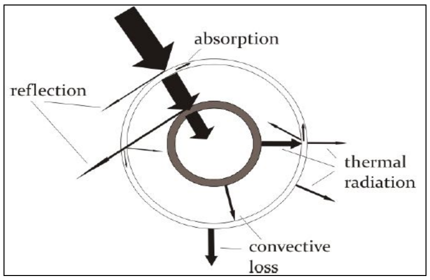

Fig 2.Losses in absorber tube

Heat transfer fluid: Direct steam generation power plants, on the contrary, contain only one fluid cycle, the steam cycle. Preheating, steam generation and (if included) superheating is realized directly within the solar field. Indirect steam generation systems use a liquid heat transfer fluid. The heat transfer medium in direct steam generation systems is the water/steam of the Rankine cycle itself

IV. PROJECT LAYOUT

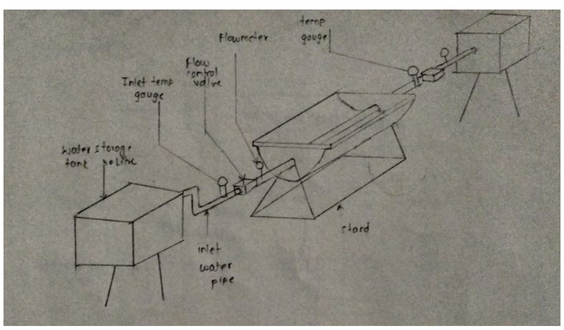

Fig. 3 Actual Project Layout

VII. OPERATING PARAMETERS

The device is first located at the place where sufficient solar radiations are available. The water tank is filled with the water and flow control valve is adjusted to ensure the required flow. Then the we have to wait for the time so as to heat the water and convert it into steam. With the help of temperature sensor we have to measure the temperature of the inlet water and outlet steam. The temp, flow and pressure are measured at the various locations and at different times of the day. The table of these parameters showing the comparison with the help of which optimization is easy.

V. CONCLUSION

From this Project we conclude that with the help of good design and advanced techniques we can harness large part of solar energy reaching the earth. The concentric solar collector is one of the good device for converting the solar energy into thermal energy and then into electrical energy with the help of turbine. There are huge opportunities to work for the project and improving the contribution of solar energy for power generation

VI. ACKNOWLEDGEMENT

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