Review Of Research
Vol. 3 | Issue. 11 | Aug. 2014
Impact Factor : 2.1002 (UIF)
ISSN:-2249-894X Available online at www.lbp.world

ORIGINAL ARTICLE

FABRICATION AND PERFORMANCE ANALYSIS OF PARABOLIC TROUGH COLLECTOR

Harbhinder Singh
Department of Mechanical Engineering, UIET, Panjab University, Chandigarh.

ABSTRACT

The solar parabolic trough collector technology is one of the most reliable technology in the field of solar thermal. This is due to the fact that temperatures as high as 300^{o}C can be achieved using this technology. This technology is used for hot water production, process steam requirement, power generation and many more. In the present study a fabrication and performance analysis on a close type parabolic trough collector is performed. Different parameters of the system such as receiver tube diameter, material of the receiver tube and heat transfer fluid are chosen for the study and evaluating the performance of the system. In the present work stainless steel with mirror finish is taken as the reflecting material for the trough. Stainless steel and copper are taken as the material for the receiver tubes. The Absorber Tube is fabricated and then painted with black paint in order to increase its absorptive and reduce losses. Water is used as heat transfer fluid. Three mass flow rates are used for the fluid. Temperatures are recorded using Thermometer. On the basis of recorded parameters efficiency of the system was calculated and its variation with time of day and mass flow rate for different conditions is represented graphically.

KEYWORDS: Solar, Collector, Design, Absorptive.

1. INTRODUCTION

The overall prerequisite of energy is persistently expanding Furthermore makes it ineluctable on making the utilization of unpredictable assets. The sun will be a standout amongst the generous energy sources that need the possibility will satisfy this climbing energy has. Sun may be a boundless Furthermore, cleaner hotspot about energy. Solar thermal technology is inexorable clinched alongside the development of the group keeping and also the country. Also, it will be paramount of the country and of the earth. Sun is a gigantic pool of clean energy also this clean force achieves earth in the manifestation of its beams is known as solar energy. Solar energy may be an abundant sourball from claiming energy Also will be accessible clinched alongside a lot. Transformation of these approaching sun oriented radiations might make done specifically or by implication clinched alongside different helpful manifestations of energy concerning illustration high temperature

The basic principle of solar thermal collection is that when solar radiation is incident on a surface (such as that of a blackbody) part of this radiation is absorbed, thus increasing the temperature of the surface. As the temperature of the body increases, the surface loses heat at an increasing rate to the surroundings. Steady state is reached when the rate of the solar heat gain is balanced by the rate of heat loss to the ambient surroundings. Solar concentrators increase the amount of incident energy on the absorber surface as compared to that on the concentrator aperture. The increase is achieved by the use of reflecting surfaces or other optical means, which concentrate the incident radiation onto a suitable absorber / receiver. Therefore, a solar concentrator generally consists of (i) a focusing device, (ii) an absorber / receiver provided with or without a transparent cover, and (iii) a tracking device for continuously following the sun. Concentrating Solar Power (CSP) technologies are usually categorized in three different concepts, as shown in figure (1.1).

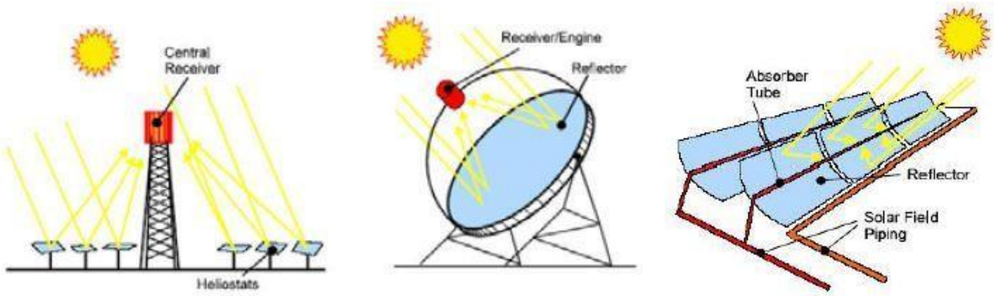


Figure 1.1: Schematic diagrams of the three CSP systems (Tower, Dish, and Trough)

- **Troughs**: parabolic trough – shaped mirror reflectors linearly concentrate sunlight onto receiver tubes, heating a thermal transfer fluid which is then used to produce superheated steam.
- **Dishes:** parabolic dish – shaped reflectors perfectly concentrate sunlight in two dimensions and run a small engine or turbine at the focal point.
- **Towers:** central receivers use numerous heliostats to concentrate sunlight onto a central receiver on the top of a tower.

The solar flux concentration ratio typically obtained is at the level of 30 – 100, 100 – 1000, and 1000 – 10000 for trough, tower and dish systems, respectively.

2. Parabolic Trough Collector

A parabolic trough collector system consists of a reflecting surface which resembles a parabolic shape. This reflecting surface is mostly made of reflecting mirrors or anodized aluminum sheets.

The solar radiations falling on the reflecting surface is concentrated on the focal line of the parabola where a receiver tube carrying the heat transfer fluid is placed. Absorber tube either painted black or electroplated with nickel or chromium in order to increase the absorptive of the tube. The heat transfer fluid picks up the heat Figure 1.2.

Parabolic Trough Collector system from the absorber tube which is utilized later in the desired way. The temperature in this type system can reach as high as 400°C, depending upon the type of reflecting surface, absorber tube materials and heat transfer fluid. A parabolic trough collector system must be positioned in agreement with the sun's position so that it can reflect the incoming beam radiations to the absorber tube.

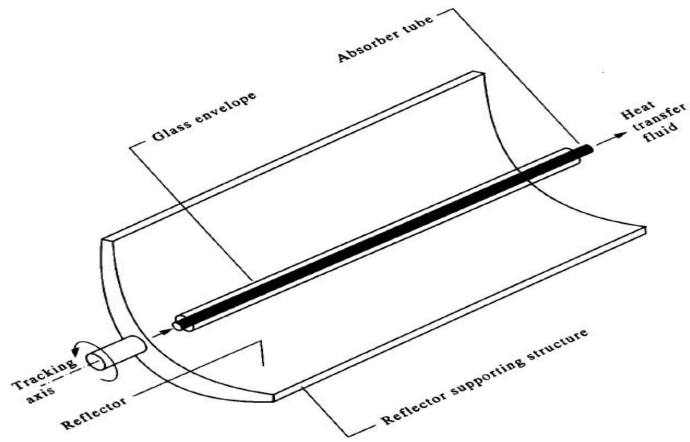


Figure 1.2: Parabolic Trough Collector system

Concentrating ratio is an important term when talking about concentrating collectors. It is defined as the ratio of the area aperture area of collector and absorber tube's area. Its value ranges from 12 to 70. Increase in concentration ratio corresponds to higher working temperatures. Various components of the system are shown in the figure 1.2.

Design specifications are shown in figure some of the chief components of the system are:

Reflector: The purpose of the reflector is to reflect and concentrate the incoming direct radiation to the focal line. This is generally made from a material of very high reflectivity, such as polished mirrors, stainless steel sheets, anodized aluminium etc. The reflectivity is as high as 90%.

Absorber tube: It acts as receiver and transporter of the energy which is being concentrated at focal line of the reflecting surface. It is made of good absorbing materials such as copper or stainless steel and is coated with black paint or other metal for increased absorptivity. It carries the heat transfer fluid to which the energy is transferred.

Support structure: It is a mechanical frame which gives the required support to sustain the weight and provide robustness against wind loads.

ADVANTAGES:

- System has high conversion efficiency.
- It can be used for power generation and steam generation.
- It can be used for community cooking purposes.
- Temperatures as high as 400^{o}C are achievable.
- It can also be utilized for thermal energy storage.

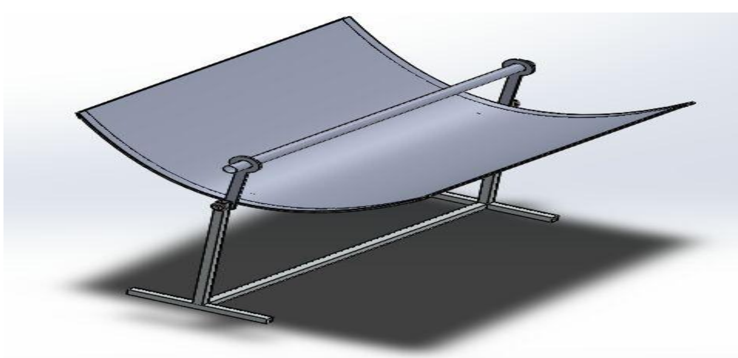
3. METHODOLOGY ADOPTED

In the present work, the methodology adopted is as follows:

1. An exhaustive literature survey has been done and research gaps have been identified.
2. Various designs and operating parameters have been identified.
3. Initially, newlydesignedparabolic trough collector is fabricated. Then experimental setup is tested and the obtained experimental results are analysed to enhance its performance with different diameter receiver pipes.
4. After that, the collector is used for water heating and experimental results areanalysed.

Drawing of PTC

All components of the closed type PTC were designed using Solid Works .The supporting structure were made by square stainless steel and the stainless steel reflective sheet is placed as observed below.



The Figure shows the base supports where the parabolic trough collector PTC will be installed with rotation axis of PTC structure, maintaining the absorber tube only a rotational degree of freedom rather than translating.

System Design

The Mass flow rate for the required temperature rise and the velocity of flow is calculated as below.

For 0.5 kW power,

Mass flow rate ($\dot{m}$) = Power/C.dt

Where, C = 4180J/kg K

dt = 8 K

$\dot{m}$= 0.0149 Kg/s

Velocity of Flow (v) = $\dot{m}/\mu.A_i$

Where, μ = 1000 kg/m^3

A_i = Cross section area of the inside of the absorber tube = 4.9087 x 10^{-4} m^2

v = 3.04 mm/s

Power Input (Solar Energy),

Intensity of Radiation (I_B) = 450W/m^2

Intensity of Radiation on the Collector = $I_B.A_C$=195.75W/m^2

Where, A_c is projected area.

Polished steel emissivity= 0.075

3.3.1Parabolic Reflector

Dimensions

Width = 0.60m Projected area (A_c) = 0.435m^2

Defining equation = X^2 = 4AY (A- focal distance) Length = 0.725m

3.3.2Focal Point Fixing

Rim angle (ϕ) = 90° Focal distance a = 13.081 mm

For optimum focal distance and curve length, a rim angle of 90° is selected for the model.

3.3.3Receiver

Stainless steel: D_i (0.025m)inner diameter

D_o(0.0265m) outer diameter

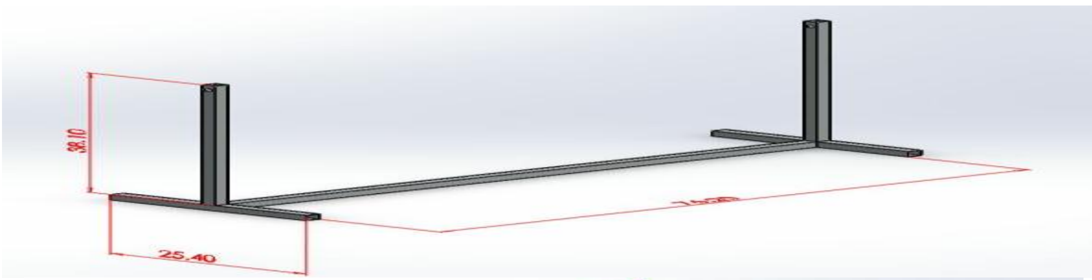
Area of receiver =πDL

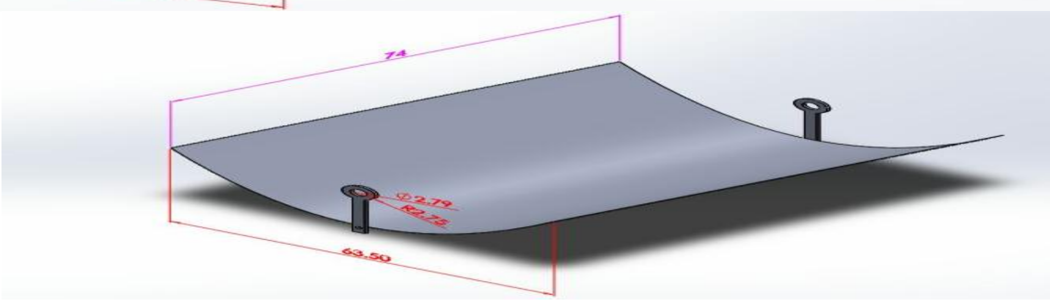
Inner cross section area=$\pi D_i^2/4=4.9087\times10^{-4}m^2$, Outer cross section area=$\pi D_o^2/4=5.154\times10^{-4}m^2$

Concentration Ratio (CR)=A_c/A_r=14.4518

3.4 Fabrication

Supporting structure is made up of SS because it is corrosion resistant material and gives rigid support.





4. EXPERIMENTAL PROCEDURE

Steps that were followed during the experimental investigation are as follows-

Step 1: To clean the apparatus in order to remove the accumulated dust

Step 2: Setting and positioning the reflector according to the sun's position. Open the water tank valve and manual track and running the system for 30 min prior to recording the first reading.

Step 3: The time gap between each reading is set to 5 min. The flow rate of the heat transfer fluid was maintained constant to ensure proper reading.

Step 4: The system was started 9:30 AM and the reading was taken from 10:00 AM to 01:00 PM by recording the data every 10 mins.

The same procedure was repeated for other readings.

The experimental procedure as mentioned above was followed throughout the experimental investigation.

5. EXPERIMENTAL RESULTS

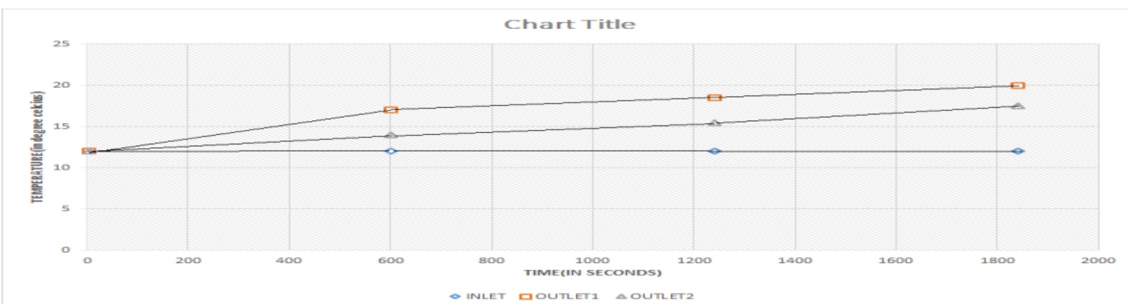
The following results are gathered from the performance analysis of the close type parabolic trough collector system.

With Black Paint:

TIME (IN SECONDS)	INLET TEMPERATURE	OUTLET TEMPERATURE
5	12	12
10	12	12
15	12	12.1
20	12	12.2
25	12	12.2
30	12	12.2
35	12	12.4
40	12	12.4
45	12	12.5

Without Black Paint:

TIME(IN SECONDS)	INLET TEMPERATURE	OUTLET TEMPERATURE
5	12	12
600	12	14
1240	12	15.5
1840	12	17.5



CONCLUSIONS

The closed type solar parabolic trough collector system is used for generation of power as the system is capable of producing high temperature. This system is also employed for water heating process, steam application and air heating as well. In this present study a close type parabolic trough collector with the stainless-steel reflecting surface is used for the performance analysis is used. In the present study various parameters such as inlet temperature, outlet temperature, ambient temperature etc. were measured. The Performance of the collector is calculated on the basis of the recorded parameters. The performance of the concentrating collector with Black Painted Stainless Steel receiver tube having diameter 25 mm is higher than the normal Stainless Steel receiver tube having diameter 25 mm.

REFRENCES:

1. Shruti Sharma, Kamlesh Kumar Jain, Ashutosh Sharma a review on "Solar Cells: In Research and Applications",Materials Sciences and Applications, 2015, 6, 1145-1155 Published December 2015

2. Askari Mohammad Bagher, Mirzaei Mahmoud Abadi Vahid, Mirhabibi Mohsen. "Types of Solar Cells and Application". American Journal of Optics and Photonics .Vol. 3, No. 5, 2015, pp. 94

3.Book of "Wind and Solar Power Plants" by Mukund Patel, CRC Press

4. N. Gupta, G. F. Alapatt, R. Podila, R. Singh, K.F. Poole, (2009). "Prospects of Nanostructure-Based Solar Cells for Manufacturing Future Generations of