ISSN: 2348-4098
Volume 3 Issue 2: 2015

DESIGN & DEVELOPMENT OF SOLAR PARABOLIC DISC COLLECTOR FOR BETTER PERFORMANCE OF HEAT STORAGE INSIDE ABSORBER CYLINDER

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ABSTRACT

This research work focuses on the development of the performance output of the solar parabolic disc collector. This paper compares two materials that are commonly used for heat exchangers in parabolic focal point. It discusses the operational parameters, with regard to heat transfer and rate of formation of steam inside cylinder. Following, it presents the advantages of Copper, Aluminium, Mild Steel, Brass and Bronze as the material for the thermal conductivity of heat exchange between absorber surface and water. Paper shows a comparison between the different materials. The paper concludes with a summary of the points covered and plot graph for their observed temperature for easy comparison. It increases formation of steam and their utilization to various purposes and also reduces the complexity of the system.

Keywords: Parabolic disc, SPDC, Transmission losses, Power output, & Converter etc.

1. INTRODUCTION

Solar incident rays or light energy are more powerful source and a renewable source of energy. It has obvious more advantageous over non-renewable energy sources such as: coal, oil & natural gas. It is safe, non-polluting, and reliable; work fast as due to increasing temperature. It is even most advantageous than other renewable energy sources, including wind and water power. It only has one drawback i.e., solar power energy can only be produce when the sun is shining. Solar concentrators are optical devices which increase the amount of incident energy on the absorber surface as compared to that on the concentrator aperture. Incident light is more absorbed at absorber by the use of reflecting or refracting surfaces. A solar parabolic disc collector mainly consists of (a) a focusing device (b) an absorber provided with or without a black paint (c) a tracking device.

Materials are very important chemical elements, which have a various characteristics and properties. They are good conductor of heat and electricity, also used in the vehicle, utensil and other household items. Metals have properties of oxidized and corrode easily. Metal include copper, aluminium, brass, bronze, silver, and irons, steel, tin, lead, magnesium, platinum, mercury etc. We used some of the metals in the form of cylinder to extract large amount of heat from there surface.

2. MATERIAL DESCRIPTION

2.1 COPPER

It has a chemical element which is used as a base metal and is oxidized easily. It has very high thermal and electrical conductivity. It is used in the purest form and is very soft and malleable. It is a gold and silver. It have a property of recycle and soluble in water.

- Copper is having a radish orange colour while a brass is usually yellow because of zinc content.
- Copper is softer while brass is high pitched and bright sound.

2.2 BRASS

It is alloy material which is formed by copper and zinc. It has a various uses such as to make door knobs, lock gears, valves, electrical and musical instrument etc. It can be casted and moulded easily because it is malleable. It has a colour of orange, yellow and brown having a different range.

- It is difficult to mould and cast.
- Copper has better finish than brass.

2.3 BRONZE

It is alloy which is formed by copper and tin. It is having more toughness due to harder then raw iron. It has a property of hardness, corrosion resistance then brass. It is more expensive.

2.4 ALUMINIUM

It is also a metal having a attributes of material. It has various properties such as corrosion resistance, flexible and good conductor. It is also light weight and good cost effective properties. It has very high heat exchange properties and has low density. It is having a different properties and easy to clean nature.

- It is hard and smooth surface which help to destroy bacteria growth and easy cleaning method.
- It is computable and light weighted.

2.5 MILD STEEL

Steel contain the carbon in small amount. Composition of carbon is taken as 0.15%. It widely used in the

ISSN: 2348-4098
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construction. It is a class of very strong and tough steel. It contains low quantity of carbon between (0.2 to 0.24%).

Table 1.1: Material properties of different metals as absorber cylinder

Material	Density (kg/m^3)	Specific heat (kJ/kg k)	Thermal conductivity (W/m °C)
Mild steel	2707	0.42	57
Brass	8520	0.347	111
Bronze	7950	0.435	26
Aluminium	2720	0.295	83
Iron	7897	0.452	73
Steel	7833	0.465	54
Copper	8954	0.383	386

We know the Heat is generally passes through conduction to solids in comparison to liquids & gases at considerably high rate and also heat transfer rate for metal occurs at highest rates.

Rate of conductive heat transfer are generally affected by two variables are:

1- Area through which heat is transferred.
2- Thickness of the metal body.

Key design parameters for optimizing the heat-exchange process in a condensing cylinder boiler are as follows:

• Thermal conductivity of the material used.

• Wall thicknesses.

• Surface area (the larger the better).

• Flow characteristics (on both sides of the heat exchanger).

• Heat exchanger weight & exchanger size.

• Heat exchanger reaction time to changing heat loads

3. EXPERIMENTAL SETUP

The setup of our SPDC is being constructed by study of different paper and mathematical analysis. It has a frame of parabola, and frame support the parabola structure and tracker is at definite place to provide the proper movement of parabola. For the better performance design and fabrication is in consideration throughout the paper. We used the cylinders as a boiler of different material with having two pipes with an inlet and outlet of 8mm joining through the gas welding. It has two valves on the pipe for controlling the inlet water supply and the steam generating in the cylinder.

We have constructed the parabolic disc collector size of 49 inches in the diameter and having X-axis of 1, 2, 3, 4inches as its depth. A reflector sheet is taken to cover the parabola of 4x8m in size and of 3x1fit. The sheet is being cut on the several pieces approx of 24 as like a leaf cut to be settled in the frame. In this experiment we have taken servo gear motor for tracking instead of sun tracker which is being attached by the stabilizer at 1.5v supply for tracking the sun. It has very high rpm to control the movement of servo gear motor as tracker.

We have discussed earlier that the cylinder we used are of different materials like as mild steel, aluminium cooker, bronze, steel etc as used for consideration. We used basically the mild steel cylinder as a boiler of having a capacity of 2 litre water and of diameter of 16 cm. It has been coloured with black outside for absorbing more heat. To check the environmental temperature alcohol thermometer is used, digital anemometer is used for measuring the wind velocity, and Digital Multimeter is used for measuring the change in voltage output power.

Fig-1: Figure shows a Experimental setup of Parabolic disc collector

4. PERFORMANCE ANALYSIS

The equation of overall output Q_{out} for the Ambient and the operating temperature "T" is taken for parabola disc collector is as below:

$$\mathbf{Q_{out} = F'[\gamma A_{in} q_{in} - U.A_{rec}(T - T_a)]}$$

$\mathbf{A_{in}}$:Incident solar Area (m^2).

$\mathbf{q_{in}}$: Irradiation incident by solar (W/m^2)

$\boldsymbol{\gamma}$: Optical efficiency of solar

$\mathbf{A_{rec}}$:Receiver Area of cylinder (m^2)

$\mathbf{T_a}$: The ambient temperature of focal point (°C)

U : The heat loss coefficient of enviorment (W/m^2K)

F' : Collector efficiency factor

The Factor $\mathbf{A_{in}/A_{rec}}$ratio means solar incident radiation area to the area of receiver is called the concentration ratio.The collector efficiency(η_c) at an operating temperature "T" is:

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$\eta_c = Q_{out}/A_{in}q_{in} = F'[\gamma - U.A_{rec}(T - T_a)/A_{in}q_{in}]2$

5. OBSERVATION AND RESULTS

As per observed data; the overall efficiency of the solar parabolic disc collector of (type1 & 2) is calculated using equations at different temperatures. Experiment on the solar parabolic disc collector with changing the different materials of cylinders was performed in the clear days of June in Jaipur, Rajasthan, India (21/06/2014-28/06/2014) period. The test was taken between 10:00 AM and 3:00 PM solar time.

As per the experimental data and calculation of maximum peak focal point temperature for the day is 229°C at 1:30PM. Focal point temperature is change for a day but increases between 10:00AM – 2:00PM and it was decreases after 2:30 PM. Variation was recorded every second due to the tracker displacement with sun inclination, wind velocity, changing weather condition and turbulence in the atmosphere surrounded. We used litres of water inside 2 litre cylinder (as boiler), boiling took place in less than 30 minutes. The overall output of solar parabolic disc collector is shown in the graph, heat trapped by the copper cylinder is maximum (210-230°C) and the overall output of the setup is found to be better which is very good sense for the thermal efficiency of the system.

6. ANALYSIS OF RESULT AS PER GRAPH PLOTTED

Graph plotted as per observed reading detail of temperature for a day, explaining and optimising the beast configuration as per detail temperature data. Graphs have plotted for 7 days reading to configure the best results. The Factor A_{in}/A_{rec} is concentration ratio, is heighest for the best configeration. Illustration of graph as per day.

DAY 1

Cylinder- Copper material

Date: **21/06/2014**

Wind velocity: **3.84 m/s**

South facing tilted at 26°

Fig. 6.1 shows the temperature variations of a full day recorded time in the graph, taken during the experiment. The highest temperature for a 1st day is 228°C recorded. As expected, it increases in the morning to a peak value at noon and starts decrease in the afternoon. Focal point temperature was as expected. Variation in the graph has clearly shown for temperature rise and fall. This variation has negative effects on the overall efficiency. The day starts with the temperature of 87°C at 10:30AM and rises to 227°C at 1:30PM. After that it falls slowly but at 3:00 PM it starts decreasing temperature very fast.

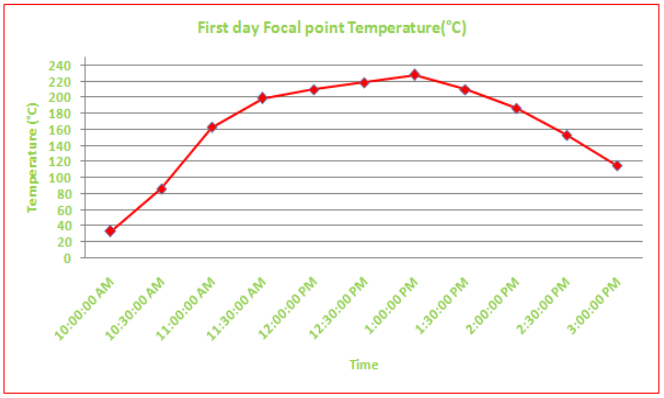

Fig-2: First day focal point temperature graph plotted between (Temperature vs time).

DAY 2

Cylinder- Mild steel material

Date: **23/06/2014**

Wind velocity: **3.65 m/s**

South facing tilted at 26°

Mild steel metal is used as cylinder to absorb the better temperature and starting with lower temperature is 27**°C** and maximum temperature is 218**°C** shown in the graph.

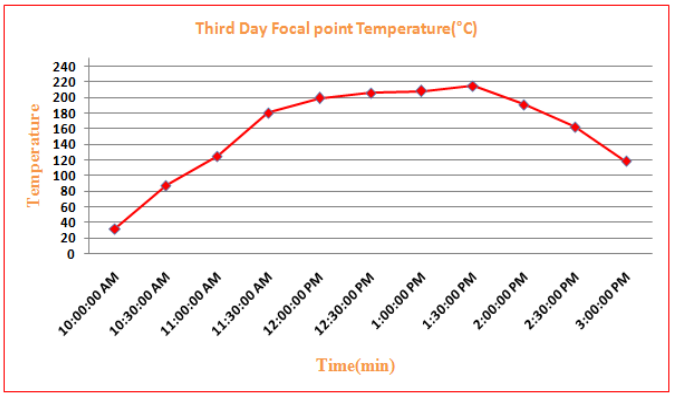

Fig-3: Graph plotted for Third day focal point temperature.

DAY 3

Cylinder- Aluminium material

Date: **25/06/2014**

Wind velocity: **2.91 m/s**

South facing tilted at 26°

Aluminium metal is used as cylinder to absorb the better temperature and starting with lower temperature is 40**°C** and maximum temperature is 223**°C** shown in the graph.

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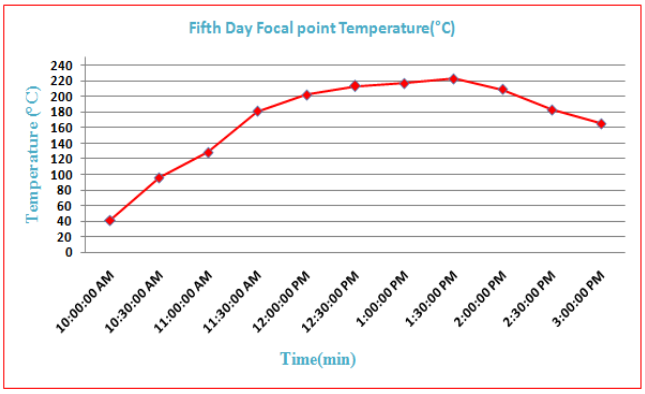

Fig-4: Graph plotted for Fifth day focal point temperature.

DAY 4

Cylinder- Brass material

Date: **26/06/2014**

Wind velocity: **3.00 m/s**

South facing tilted at 26°

Brass metal is used as cylinder to absorb the better temperature and starting with lower temperature is 28**°C** and maximum temperature is 217**°C** shown in the graph.

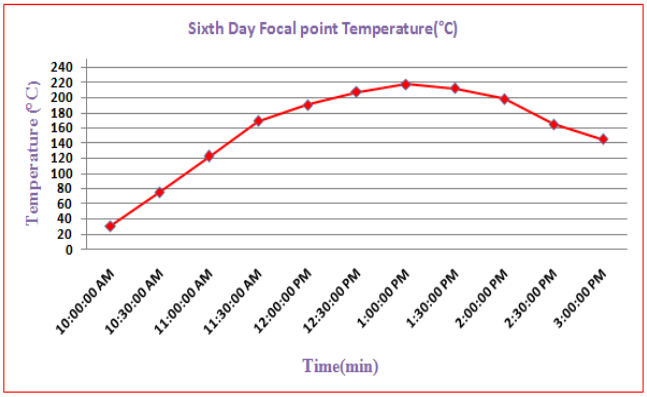

Fig-5: Graph plotted for Sixth day focal point temperature.

DAY 5

Cylinder- Bronze material

Date: **27/06/2014**

Wind velocity: **2.85 m/s**

South facing at 26°

Bronze metal is used as cylinder to absorb the better temperature and starting with lower temperature is 30**°C** and maximum temperature is 216**°C** shown in the graph.

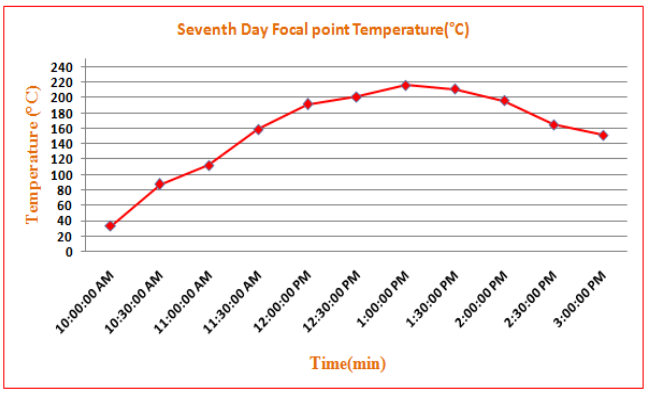

Fig-6: Graph plotted for Seventh day focal point temperature.

6.1 AVERAGE TEMPERATURE

Wind velocity is **3.1m/s**

Maximum Temperature is **229.28°C**

With the detail analyzed data, it is recorded that average for **7 days** and a graph plotted for the average focal point temperature is shown below. It is seen from graph **that average temperature for hours 1:00pm is higher for a 7 days daily data** and it is found that average temperature is **217.85°C and** it is very better temperature to produce as much heat to run the turbine and produce as much electricity to run the small home.

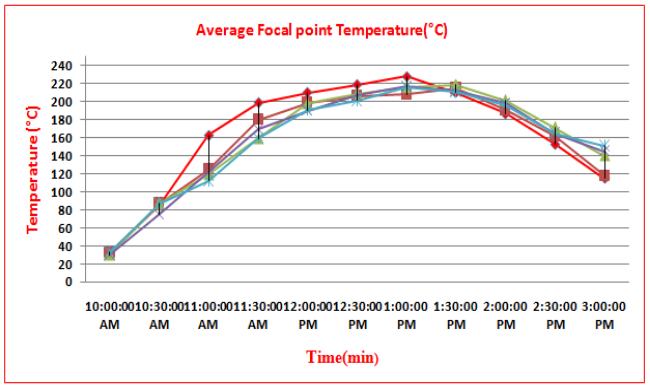

Fig-7: Graph plotted Average focal point temperature

From the above all the graph of Seven days, it is seen that Copper material have a high rate of Heat and mass transfer from the cylinder bottom surface focal point to the water. Gauge of the cylinders are same is approx to be 0.05mm of all the materials of cylinder. As compare to mild steel with copper, copper again shows the temperature larger than that of mild steel and it is higher. With same to Brass and bronze comparing to copper we found the better result to copper is shown in the graph.

Here, all such variables affected the results and the further gain of temperature is also a good sense to produce electricity. The used metals cylinder shows the temperature in between **(210-230°C)** is too good for us, but all metals cylinder in comparison with each other the copper shows the best results and is **(5-15°C)** more than the other metal cylinder. Finally, copper cylinder is good

ISSN: 2348-4098
Volume 3 Issue 2: 2015

to take as cylinder for this type of configuration and thermal efficiency will be increased by utilising this as cylinder.

7. CONCLUSION

After the several study of the various material and their analysis on the experimental setup of solar parabolic disc collector the changes have been recorded. Enormous amount of variation have been recorded to the disc and sets of conclusion. According to the results of taken data the sets of following conclusion are obtain at different points of reading are:

- Temperature inside copper cylinder is 228°C observed maximum is very good sense of efficiency to produce the power from the steam generated inside the cylinder.
- Due to solar irradiance, maximum heat generated by copper and aluminium cylinder is having high thermal efficiency and better output to power.
- Better geometry of parabola frame means having change in x-axis =4, 5, or 6 have a large area of incident rays trapping inside the parabolic disc will increase the thermal efficiency.
- Single axis tracker movement is kept proper to track the incident sun ray because high accuracy to focal point and surface of cylinder increases the overall efficiency.
- Focal point temperature and inside cylinder was found to be 229°C maximum on the first day at 1:30PM and the different material such as- brass, bronze and mild steel is also quite good for achieving the efficiency at lower cost.
- Time increment in a day increases the day temperature at peak and decrement is also seen with declination of sun rays at focal point.

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