Analysis of solar parabolic trough collector system for heating water

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1. Introduction

The government set the target for renewable energy of 175GW which include 100GW for solar. Ministry of renewable energy started implementing and supporting various schemes to achieve the target. Solar energy is one of the prime sources of renewable energy. The United Nations Food and Agricultural Organization (FAO) states that 55% of the "round wood" (trees cut down for some type of human use) cut in a year is used for domestic purposes. The cutting of firewood for cooking causes deforestation, leading to desertification. Collecting and harnessing solar power has not been as easy or convenient, as it has been for other energy sources, for several reasons. First, the energy from the sun is spread over a wide area in a relatively low energy form. Unlike petrol and coal, which are high-energy and can be easily transported, solar energy is available in a scattered manner, and is difficult to usually trap, convert and store. In order to collect it, solar energy harnessing equipment must be utilized. Further, solar energy is not available at night or during overcast and cloudy weather, and the forms of energy derived from solar energy must be stored. Among the available technologies for thermal storage systems, the latent heat thermal energy storage system can store a great amount of thermal energy in a small volume at constant temperature, and hence, this type of energy storage system is often used for different applications. There is abundant amount of solar energy in India, but utilization of this energy is on a very small scale, the photovoltaic panel industry is leading the solar extraction system but with a major flaw that is its very low efficiency around 16%, there is need for high efficient system to be utilized over the photovoltaic system. The research on Thermal Energy Storage (TES) is very essential for effective utilization of solar energy. Wang at al. 2015, studied the effects of glass cover on heat flux distribution for tube receiver with parabolic trough collector (PTC) system. Xu et al. 2014, proposed end loss of PTC. Kalogirou 1996, studied various characteristic of PTC for low temperature power generation. PTC and their applications were proposed by Fernndez-Garca et al. 2010. Garca et al. 2011, proposed performance model for parabolic trough solar thermal power plants.

2. Material aspects

Based on the extensive studies for suitable materials for the various parts of the solar collector based on their thermal, mechanical and chemical properties. Various properties are desirable for the various parts of the parabolic collector.

The property of the material that is to be used for coating should be such that it should be able to withstand high temperatures, have better reflectivity, should be resistant to corrosion and also should have low transitivity and absorptivity. For this purpose silver seems to be an ideal candidate, but due to the high cost and requirement of heat treated bend glass plate and high cost of silvering and difficulty in maintaining the silver coating and requirement of extreme care while handling the same, makes it not an economically viable solution to the reflective surface. It was decided that mirror coating stainless steel is used as a reflective material because of its optical efficiency is 70% to 85%. Another advantage of using mirror coating stainless steel is its long life and very small corrosion. It is also wind-loading deformation free.

The material used for the structure should be more resistant to compression than tension. It should have high strength and capable of taking fatigue loading and should have good resistance to corrosion. Mild steel is the most preferred material for the purpose. The material used for making the pipe section should be a good conductor of heat, should be able to maintain its properties for sufficiently high temperature, it should have good absorptive and good conductance and preferably, low emissivity to avoid radiation losses from the pipe section. It should be able to resist corrosion. On the inner surface, the working fluid is ordinary water, which can lead to calcification, and rusting. The outer surface being exposed to the atmosphere should also have some kind of protection mechanism. It is preferred to use copper tubes of diameter 30mm considering the required mass flow rates and good heat transfer properties.

Table 1: A summary of the various materials to be used

Usage	**Materials**
Back plate	GI
Receiver	Glass tube
Structure	Wood
Reflecting surface	Aluminum reflecting sheet

3. Design of Parabolic Reflector

The dimensions of closed type PTSC were taken and designed so that it is feasible for easy installation and transportation.

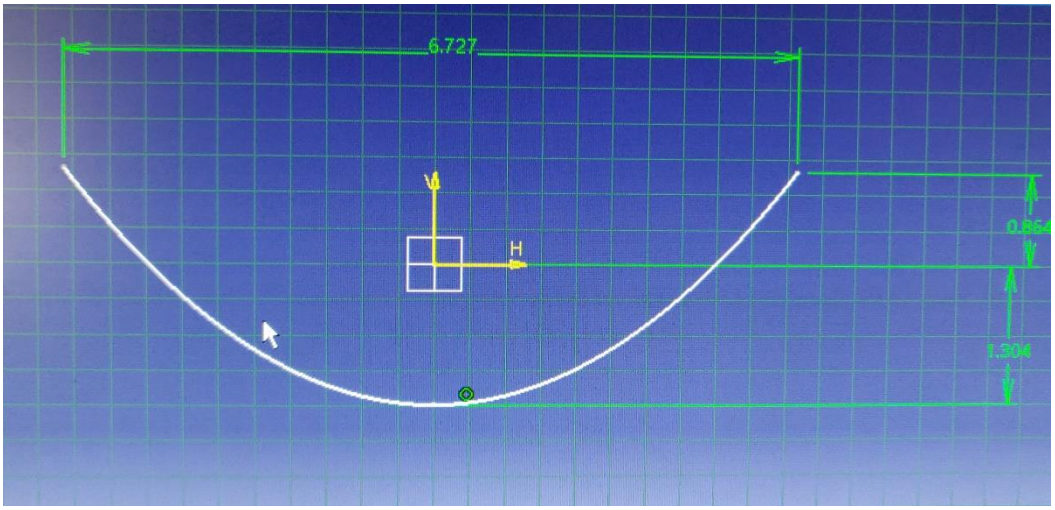

Figure 1: parabolic curve for collector

The dimensions of the collector can be seen in table 2.

Table 2: Dimensions of collector

Item	Sample	Value
Length	L	1.2192m
Aperture	α	2.042m
Focal length	*f*	0.35m
Receiver diameter	d	47 mm OD 37 mm ID
Geometrical CR	C_g	33.45, 25.07, 20.06
Concentrator height	*h*	0.35m

4. Results and discussion

The average temperature range was 77.1 degree Celsius. The peak temperature was 82 degree Celsius. This output water temperature is feasible for boilers. The maximum temperatures was achieved around 12 pm.

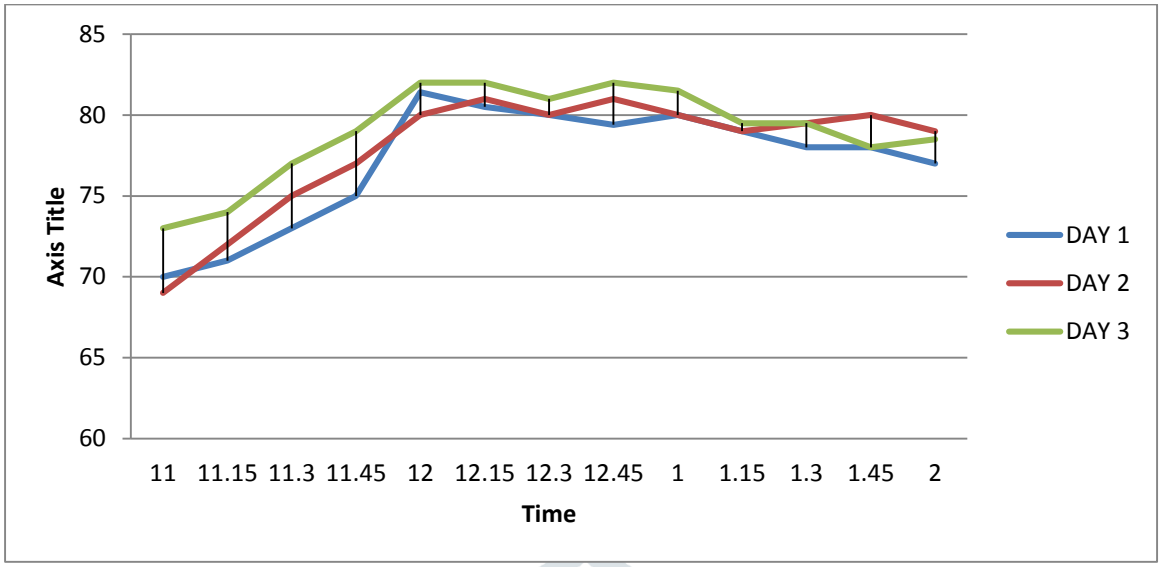

Fig. 2: Variation of Outlet Temperature With respect to time with discharge 66 ml/min to 67 ml/min

5. Conclusions

The 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. The performance of the concentrating collector varies with respect to the day hours, as solar intensity varies through this period.

References

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