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Methodologies to improve temperature difference for power generation from Parabolic Collector using Peltier effect

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Abstract— The parabolic collector utilizes the radiation of sun for useful work. In general, the production of useful energy from solar energy is classified into electrical and non- electrical based methods. In non- electrical based methods, the reflector and absorber is used to convert the heat energy from sun into useful work, Such as heating of water and for cooking. In electrical based methods, the solar PV cell absorbs the sun's radiation to generate electricity. In addition to solar PV Cell, the peltier effect is used to generate electricity. The parabolic collector reflects the sun's radiation towards the absorber which is made with hot and cold end. The hot and cold end generates electricity with the principle of peltier effect. The main problem in this method is the difficulties in achieving temperature difference. In this paper, the trail was conducted with components such as peltier plate (TEC1- 12703), Parabolic collector and cooling system to produce a power output of 0.25mW from a plate with maximum sun intensity and temperature difference of 25 degree Celsius.

Keywords— Peltier Effect; Parabolic Collector; Renewable energy; Thermoelectric power generation; Temperature difference.

I. INTRODUCTION

In India, the economic development is greatly affected due to demand in electricity. The renewable source of energy is one of the sources to meet the energy demand. The solar energy requires no chemical energy other than Sun's radiation which is free from pollution. Similar kind of sources, can decentralise the electricity distribution and supply to rural areas. India is a founder member in the Carbon Sequestration Leadership Forum (CSLF), Methane to Market Partnership, and International Partnership for Hydrogen Economy, and Asia-Pacific Partnership for Clean Development and Climate, Indo-EU Cooperation,etc[1]. India has the very high potential for Wind, Mini hydro, Bio-gas and Solar.

The thermoelectric power generation is one of the recent technology in the generation of clean energy from the solar power. The central receiver system with this thermoelectric power generation will be the next generation power generation technique which has the tendency to produce power in large scale.

II. LITERATURE REVIEW

Abel pifre made printing press operated by low-pressure steam from solar energy in 1878 at paris[2]. Followed with in1920 J.A.Harrington developed solar-powered steam engine to pump water up 5 m into a raised tank[3]. The angles[4] such as azimuth and altitude are to be taken for Maximum solar energy and for avoiding shades. The Zenith angle is the angle between the rays from sun and perpendicular line to the horizontal plane or angle of incidence of beam radiation on a horizontal surface. The solar azimuth angle is the angular displacement from south of the projection of beam radiation on the horizontal plane. The surface azimuth angle is the deviation of the projection on a horizontal plane of the normal to the surface from the local meridian with zero due south. The angle of incidence is the angle between the sun's ray falling on the plane surface i.e. collector and

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the normal to that surface. The hour angle is the angle through which the earth must be rotated to bring the plane directly under teh sun. The altitude is the angle between the sun rays and a horizontal plane. The working fluid can reach a temperature up to 400°C, depending on the concentration ratio, solar intensity, working fluid flow rate and other parameters [5]. The parabolic trough solar collector system was developed for thermal power generation with synthetic oil to circulate as the heat transfer fluid[6]. The thermoelectric effect is the direct conversion of the temperature differences into electricity and vice versa. When there is heat or cold at an electrified junction of two different conductors is called as peltier effect.

III. Brief Description of Components

Peltier plate (TEC1-12703) was used to convert concentrated solar energy directly into electric energy with the principle of peltier effect. The plate consists of 127 couples of p-type and n-type junctions. The plate is designed with specification I_{max} 3.3A, V_{max} 14.5v, Q_{max} 29.3W, ΔT_{max} 68 degree celsius. **Parabolic Collector** is made up of 7Anodized aluminium plate, which was cut into pieces and fitted to the parabolic frame of area 2000 square centimetre. Having the concentration ratio of 18 as in Fig. 1. **Cooling system** was designed to achieve the cold end. This is achieved by forced air circulation and Thermosymphon water circulation. Mild Steel frame was used to support all the components.

Figure 1. Parabolic Collector

IV. Experimental Setup

The parabolic collector was focused towards the sun for maximum radiation to reflect the concentrated heat energy towards the absorber plate to achieve the hot end. The cold end was achieved by the cooling system in the absorber plate. The hot and cold end forms the peltier effect which generates power. The trial was made with different cooling system to achieve the maximum temperature difference.

V. EXPERIMENTATION

The parabolic collector was positioned at certain distance below the focal point of the dish and helps to capture the reflected radiation from the collector and spread the converted heat evenly on the thermo electric cells. Absorber plate consists of cooling system to maintain the temperature difference between hot side and cold side. This trial was conducted for three days. The results are tabulated in Table 1.

5.1. Trial-1: Cooling by Forced Air Circulation

The air was circulated to remove the heat inside the absorber plate inorder to obtain the temperature difference. The circulating fan was operated with the power from 3.5V solar panel.

Figure 2. Parabolic Collector with Forced Air Circulation

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5.2. Trial 2: Natural Water Circulation

The water was circulated with the principle of Thermosymphon system, in this water inside the absorber got heated up and move towards the reservoir to obtain the natural circulation. The water was passed through the copper tube winding inside the absorber plate to increase the rate of circulation.

Figure 3. Parabolic Collector with Natural Convection

VI. RESULT AND DISCUSSION

Table 1. shows the values of average temperature(T_H & T_C) in hot & cold end and average current produced against the temperature difference obtained for 3 days for trial 1 and 2. It was observed that trial 2 i.e. temperature difference with natural convection found effective. Figure 4 & 5 shows the average temperature difference obtained for 3 days for trial 1 and 2.

Table 1. Average Current Production From Trial 1 & 2

Trial	Temperature at Hot Junction (T_H)	Temperature at Cold Junction (T_C)	Average temperature difference	Average current produced (mW)
	(^oC)			
1.	59.37	39.8	18	0.2388
2.	60.18	36.2	24.4	0.2563

VII. CENTRAL RECEIVER SYSTEM

The absorber and collector are the main components for a solar collector system [8]. In central receiver system or heliostat as in Figure. 4, the tower is used as an absorber for circulating working medium. The working medium may be water or some other salts such as liquid sodium. In such systems, the heat energy is converted into mechanical energy using steam turbine. But the thermoelectric effect can be employed in this type of system for power generation by eliminating the steam turbine.

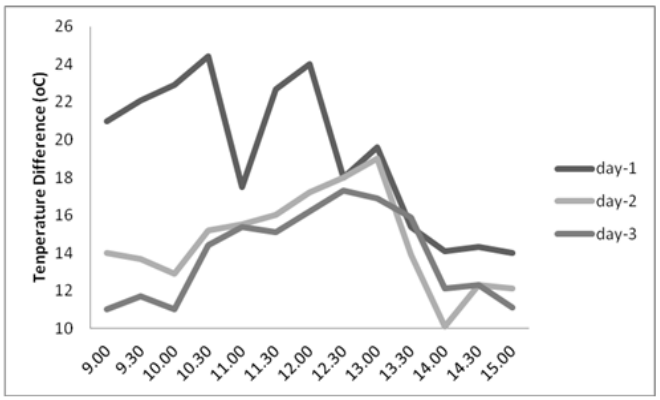

Figure 4. Average Temperature Difference For Trial-1

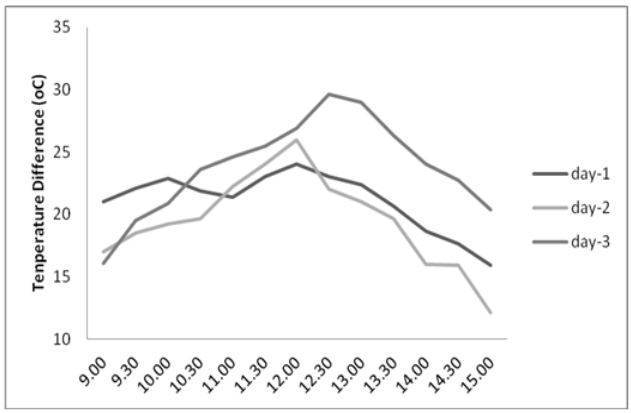

Figure 5. Average Temperature Difference For Trial-2

VIII. CONCLUSION

The power generation from the combined system of parabolic collector and thermoelectric cell was developed. The performances of the thermo electric cell are evaluated in terms of the electrical power output. In these trials, second trial can be

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considered and Maximum watts achieved in this trial is 2.155mW at 12.30hrs and average obtained is in the range of 0.2563 mW. The performances of the system is greatly affected by the temperature difference. This techniques can be adopted in central receiver system for power generation in large scale.

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