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PERFORMANCE ANALYSIS OF PARABOLIC SOLAR TROUGH CONCENTRATOR FOR VARIOUS WORKING FLUID

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Abstract: The parabolic concentration technology is very useful as it is used for approximately all solar energy applications such as steam and power generation water heating air heating etc. Solar intensity is measured by solar power meter which is calibrated with pyranometer. The large number of developments is continuously being carried out in the field of cover materials absorber materials and glazing coating etc. The studies have been carried out on thermal performance evaluation of solar water heater and found more increase in the thermal efficiency in comparison to conventional solar water heater. Thus in order to encourage and facilitate studies about the solar concentrator this paper is concerned with the detail study of parabolic trough collector. The model which is made up of reflector surface reflector support absorber pipe and stand with manual tracking arrangement was fabricated using locally sourced material for rural applications point of view. The electricity and heat produced simultaneously in photovoltaic thermal system from solar energy is about 60-70% efficient. The main objective in this project work is combining two systems; Parabolic trough as a concentrator and channel PV/T collector as a receiver.
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***Key Words* - Absorber, Parabolic Concentrator, Parabolic Trough, Receiver, Solar Energy**

I. INTRODUCTION

Solar energy consists of light and heat emitted by the sun in the form of electromagnetic radiation. Technology today helps to capture this radiation and turn it into usable forms of solar energy- such as heating or electricity. The literature review is carried out on the various fields of research on parabolic solar dish collector which is aiming to improve the performance of parabolic solar dish collector. In this following literature; the temperature in the center of the disc reaches value which is about 400 c. Active solar techniques include the use of photovoltaic panels and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the sun selecting materials with favourable thermal mass or light dispersing properties and designing spaces that naturally circulate air. A lot of energy is required in the heating of water in many part of the world mainly in the countries having colder climate. This energy consumption can be minimized by using solar energy as the source for heating water application.

Energy and water are two main issues in this century. All efforts are done to tap the solar energy and make it viable. In current scenario a need exists to develop alternative energy source which can fulfil the increasing energy needs of the world. Solar energy is a very inexhaustible source of energy. The power from the sun received by the earth is approximately 1.8*10 MW which is many times more than the present consumption rate. Solar high temperature designs need concentration systems such as parabolic reflector. The solar constant Isc is the rate at which energy is received from the sun on a unit area perpendicular to the ray of the sun at the mean distance of the earth from the sun the value of Isc is 1353 w/m. Photon emitted from sun with energy below the band gap energy cannot be absorbed by PV and is transmitted. Photon with energy greater than the band gap energy is absorbed and converted into electricity.

1.1 MEASURING DEVICES AND INSTRUMENTS

The temperatures at different points are measured using k type thermocouples. A digital temperature indicator is connected with the thermocouples that give the temperature with a resolution of 0.1 ^{0}c. The solar radiation intensity is measured during the day using a solar power meter.

1.2 METHODOLOGY

We now consider the performance analysis of a cylindrical parabolic concentrating whose concentrator has a aperture W length L and rim angle. The absorber tube has an inner diameter Di and an outer diameter Do it has a concentric glass cover of inner diameter Dc1 and outer diameter Dco around it. The fluid being heated in the collector has a mass flow rate m a specific hear Cp an inlet temperature Tfi and an outlet temperature Tfo. The collect is operated in any one of the modes and the beam radiation normally incident on its aperture is Ib rb whose value can be calculated from the equations derived.

$$n = mc_p (T_e - T_i) X 100/A_c (H_b).t$$

Fig. 1.1 Front View of Parabolic Trough Collector

Fig. 1.2 Rear View of Parabolic Trough Collector

The main objective of the work is to increase the TCPV/T system efficiency by reducing the reflectionloss of solar radiation and added cost of complexity of a pump.The following methodology is used to solve the problem:

1. As the existing TCPV/T system does not focus the reflected solar radiation in perpendicular direction there are chances for loss in reflected radiation to reduce this reflection loss the reflection loss the receiver of my proposed work is designed n V-shape which receives the radiation in perpendicular direction hence there will a minimum loss of reflected rays by this system efficiency can be increased.
2. As the receiver is covered by PV cells cooling is more important to avoid the drop in cell efficiency due to the increase in temperature. To reduce the added cost and complexity of a pump in here for the coolant flow in natural circulation is achieved by varying the height of the storage tank. And also theoretical calculation is done to valid the mass flow rate and corresponding calculations are made.

II. MATERIALS & METHODS

A photovoltaic cell (figural) comprises P-type semiconductors with different electrical properties joined together. The joint between these two semiconductors is called the "P-N junction". Sunlight striking the photovoltaic cell is absorbed by the cell. The energy of the absorbed light generates particles with positive or negative charge (holes and electrons) which move about or shift freely in all directions within the cell. The electrons (-) tend to collect in the N-type semiconductor and the holes (+) in the p-type semiconductor. Therefore when an external load such as an electric bulb or an electric motor is connected between the front and back electrodes electricity flows in the cell.

A parabolic trough is a type of solar energy collector. It is constructed as a long parabolic mirror (usually coated solver or polished aluminium) with a Dewar tube running its length at the focal point. Sunlight is reflected by the mirror ad concentrated on the Dewar tube the trough is usually aligned on a north-south axis and rotated to track the sun as it moves across the sky each day. The first practical experience with PTCs goes back to 1870 when a successful engineer John Ericsson a Swedish immigrant to the United States designed and built a 3.25-m-2-aperture collector which drove a small 373-W engine. Steam was produced directly inside the solar collector (today called Direct Steam Generation or DSG). From 1872 to 1875 he built seven similar systems but with air as the working fluid.Parabolic trough currently represents the most cost-effective solar technology for developing large utility-scale electric power systems. These systems are also one of the most mature solar technologies with commercial utility-scale plants that have been operating for over 20 years.

Fig. 2.1 Parabolic Trough Collector Setup

Solar line concentrators are primarily installed parallel to the ground and have rotating focus. These are mostly used for power generation through steam route. A parabolic trough is a type of solar thermal collector that is straight in one dimension and curved as a parabola in the other two. It has a lined with a polished metal mirror. The energy of sunlight which enters the mirror parallel to its plane of symmetry is focused along the focal line where objects are positioned which is intended to be heated. For example food may be placed

III. RESULTS AND DISCUSSION

The solar radiation falling on the concentrator is reflected to the receiver (absorber tube) located at the focal line through which working fluid runs and which is covered by concentric-transparent glass cover. As the temperature in the receiver rises, heat transfer processes starts. Energy in transition under the motive force of a temperature difference between components of the collector forms the basis for the determination of heat gained and heat losses to and from one component to other.

The elementary components for thermal analysis of the PTC are as follows:

1. The concentrator or reflecting surface.
2. A receiver assembly consists of a circular receiver tube with selective coating, enclosed inside a concentric-transparent glass-cover.
3. The working fluid.

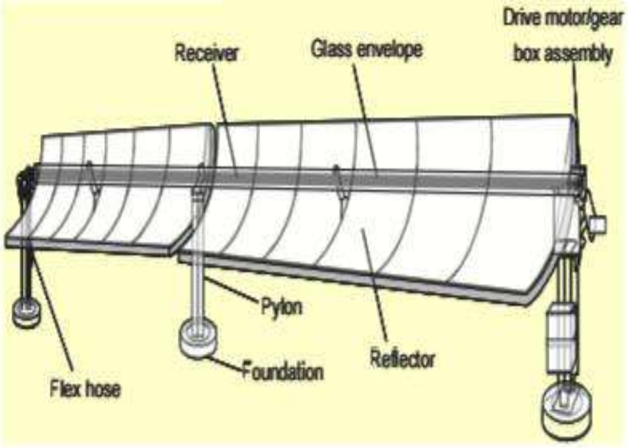

Fig. 3.1 Parabolic Trough Collector.

Energy balance equations for a PTC by Egbo [6] considered the heat-energy-gain, the heat energy-loss and the heat-energy-transfer between the components, i.e. the reflecting surface, the glass-cover and the absorber-tube, the thermal properties of the materials of the components and geometric dimensions of the PTC. Graph shows diurnal variation in the hourly efficiency of stainless steel reflector with time.

From above plot it is clear that the efficiency initially increases from 10 am and it reaches to its maximum values 44.82% at 3.30 pm and it is decreases suddenly after 3.30 pm. It is because of increment in the solar intensity during the same period. Graph shows diurnal variation in the hourly efficiency of aluminum sheet reflector with time. The nature of the plot is like a pyramid. From above plot it is clear that the efficiency start to increase from 10.00 am it reaches to its maximum value 51.04% at 1.40 pm and it is decreases slowly after 1.40 pm. It is solar intensity during the same period.

Fig. 3.2 Variation in hourly efficiency with time Aluminum Sheet reflector

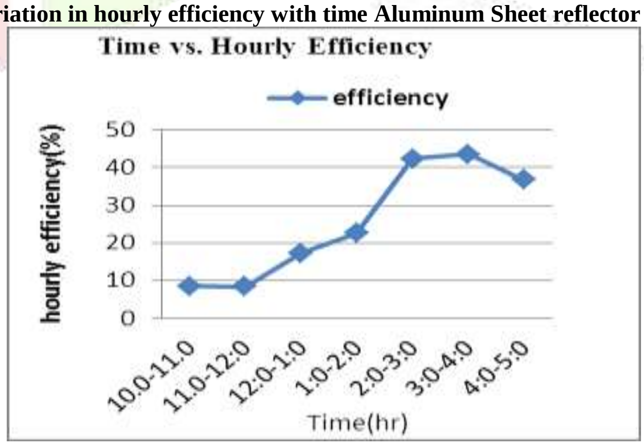

Fig. 3.3 Variation in hourly efficiency with time silver foil reflector

Graph shows diurnal variation in the hourly efficiency of silver foil reflector with time. From above plot it is clear that the efficiency initially it was constant upon 11 am after 11 am it increases and it reaches to its maximum value 43.44% at 3.30 pm and it is decreases slowly after 3.30 pm. It is because of increment in the solar intensity during the same period.

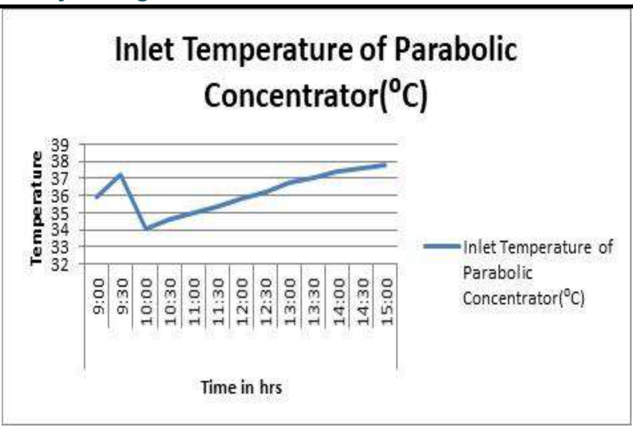

Fig. 3.4 Inlet Temperature of Parabolic Concentrator

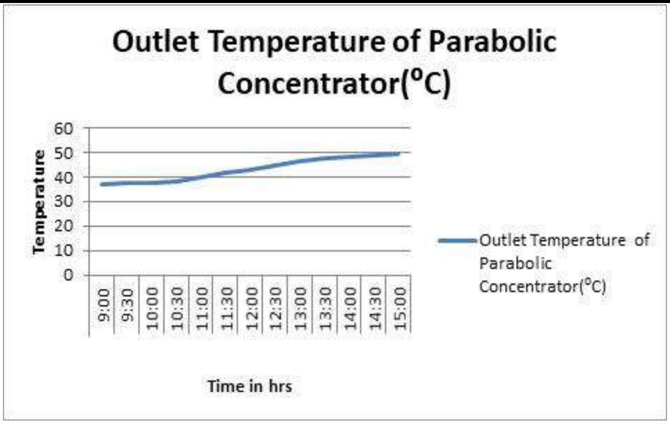

Fig. 3.5 Outlet Temperature of Parabolic Concentrator

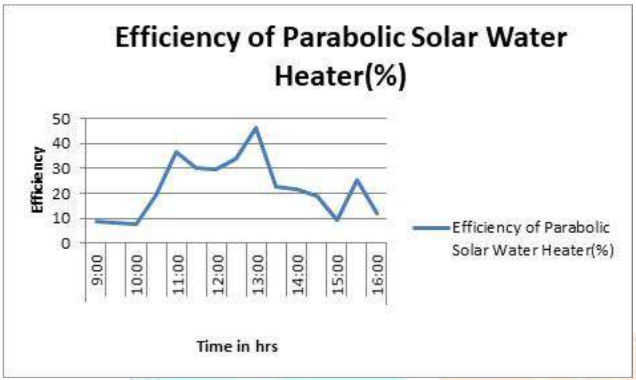

Fig. 3.6 Efficiency of Parabolic Solar Water Heater

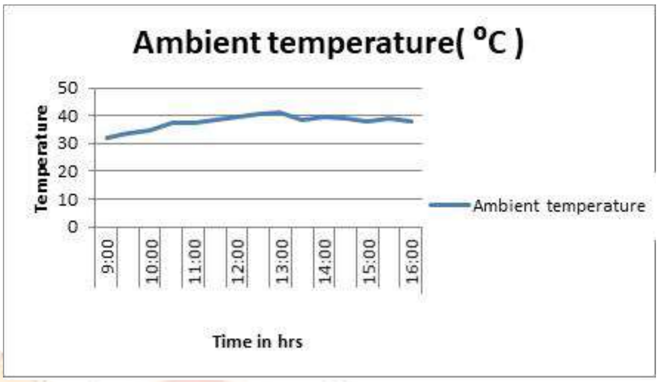

Fig. 3.7 Ambient Temperature

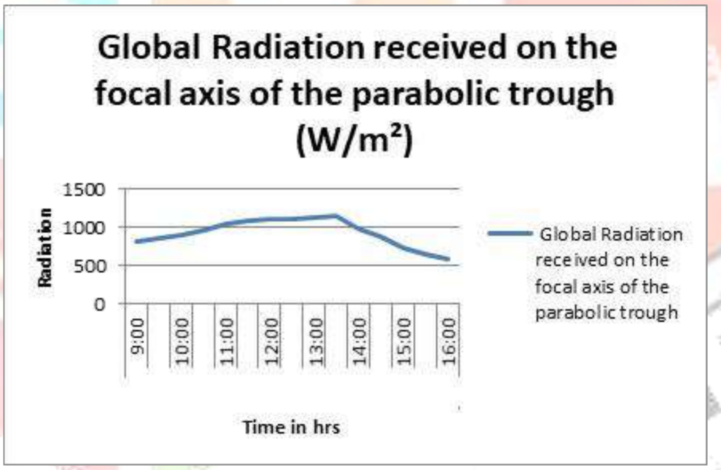

Fig. 3.8 Global Radiation received on focal axis of Parabolic Concentrator

The experiments were carried out at Poornima University Jaipur (latitude of 26.91 N; longitude of 75.78 E) India. Various parameters were measured during the experiment such as parabolic trough inlet temperature Hot Water Tank outlet temperature hot Water Tank output Temperature Ambient Temperature Radiations received on the focal axis of the parabolic trough etc. The parameters were measured in every 30 minutes from 09.00 .m. in the morning to 04.00 pm in the evening. Test data for 1^{st} August 2019.

IV. CONCLUSION

In this work experimental and performance analysis of parabolic solar dish collector carried out with use stainless steel, silver foil and aluminum sheet as reflecting Materials. Here we studied the useful heat gain, Instantaneous efficiency, hourly efficiency and overall efficiency (shown in graph) of all above three different reflecting materials. The maximum value of each of those parameters is observed around noon, when the incident beam radiation is at its peak. The fabrication and design of a solar parabolic trough using locally available materials is possible hence low temperature trough will be a better solar thermal device for the rural and remote area. Even if there are many PTC design available losses like cosine losses, end loss effect, heat losses from the HTF are common which have the potential in improvement of the design and hence increase in the efficiency of the whole system. The system gives the maximum efficiency of 48.26 % with outlet temperature of 83°C of water and 53°C of storage tank water. Number of Carbon Credits that we can earn by saving monthly 5046506565 kWh of Electricity i.e. saving 5298831.89 tones of CO2.The results obtained can help engineers in the evaluation of the existing real systems and design of future system.

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