Performance Analysis of Parabolic Solar Dish Collector for Various Reflecting Materials

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Abstract—*The Parabolic Dish Solar Collector 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. In this paper work the performance analysis of parabolic solar dish collector is done with the use of different reflecting materials. In this work a Parabolic Dish Solar Collector system is fabricated for hot water production. Water is used as a working fluid and is recirculates from the storage tank to the absorber tank with the help of a pump. The main aim in the work is to increase the temperature of water in the storage tank to a maximum value. An analysis is mainly concentrated on the reflector material. The values of useful heat gain, overall thermal efficiency, instantaneous efficiency and hourly thermal efficiency are calculated and their variation with time and solar intensity are represented graphically. To begin with stainless steel sheet is used as reflector and performance is compared with using aluminium sheet and silver foil as reflector. Solar intensity is measured by solar power meter which is calibrated with pyranometer.*

Key Words: solar, power, meter, reflecting, efficiency, Tracking etc.

1. INTRODUCTION

With the growing population and fast pace of development, energy is becoming more expensive and our cities and towns face a major power crisis. The reality is that resources like coal, oil and natural gas will not be around forever. We all realise today, that we need alternatives sources of energy that are renewable. Renewable energy is derived from natural resources such as sunlight, wind, tides and geothermal heat. Solar energy is one of the most promising future renewable energy sources as reflector.

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;

El Ouederni et al. [1] developed parabolic solar concentrator. Experimental measurements of solar flux and temperature distribution on the receiver have been carried out. The solar flux concentrated on receiver has been experimentally determined. The obtained results describe correctly the awaited physical phenomenon. The temperature in the center of the disc reaches a value which is about 400 °C. So that, a good quality of industrial high temperature equipment's, can be obtained using this technology of solar energy concentration. The second result was the good efficiency of the studied solar concentrator which can be increased by different interventions. In another term, using this solar equipment we can extract eventually 27 % of direct solar energy and convert it into thermal energy that can be used directly for several applications such as water heating, electricity generation using Stirling engine, vapour production, etc.

Lifang Li et al. [2] developed a new concept for designing and fabricating large parabolic dish. The dish mirror was formed from several optimal-shaped thin flat metal petals with highly reflective surfaces. Attached to the rear surface of the mirror petals were several thin layers whose shapes optimized to reflective petals form into a parabola when their ends were pulled toward each other by cables or rods.

Ibrahim et al. [3] reported the design and development of a parabolic dish solar water heater for domestic hot water application. He found that the heater is providing 40 liters of hot water a day for a family of four members, assuming that each member of the family requires 10 liters of hot water per day. Initially he expected the thermal efficiencies of 50% by the design but he obtained thermal efficiencies of 52% - 56% and this range of efficiencies is higher than the expected designed value.

Fareed. M. Mohamed et. al [4] studied Portable Solar Dish Concentrator and reported design and fabrication of solar dish concentration with diameters 1.6 meters for water heating application and solar steam was achieved .The dish was fabricated using metal of galvanized steel, and its interior surface is covered by a reflecting layer with reflectivity up to (76 %), and equipped with a receiver (boiler) located in the focal position. The dish equipped with tracking system and measurement of the temperature and solar power .Water temperature increased up to 80 0C, and the system efficiency increased by 30% at mid noon time.

Eswaramoorthy et al. [5] conducted an experiment on small scale solar parabolic dish thermoelectric generator. They fabricated solar parabolic dish collector using an unused satellite dish antenna fitted with polished aluminum sheet as concentrator surface. The concentrated solar radiation and water cooled heat sink was the driving potential to generate electricity; they studied various operating parameters like receiver plate temperature, power output and conversion efficiency with respect to solar radiation. From the experiment it was found that the receiver plate temperature was significantly affecting the power output.

Parabolic dish solar thermal cooker was designed and constructed by Ibrahim **Ladan Mohammed (6)**. The cooker was designed to cook food equivalent of 12 kg of dry rice per day, for a relatively medium size family. For effective performance, the design required that the solar cooker track the sun frequently, and a linear actuator (super jack) was adopted for this purpose. Preliminary test results show that the overall performance of the solar thermal cooker was satisfactory. The cooker was capable of cooking 3.0 kg of rice within 90 – 100 minutes, and this strongly agrees with the predicted time of 91minutes.

Yadav et al. [7] investigated a solar powered air heating system using parabolic trough collector using different reflectors. In this experiment, the reflected solar radiations were focused on absorber tube which was placed at focal length of the parabolic trough. In this setup, air was used as working fluid which collects the heat from absorber tube. He used three different reflectors for analysis and they observed that performance of Aluminum sheet is excellent as compare to steel sheet and Aluminum foil as reflector.

2. EXPERIMENTAL SETUP

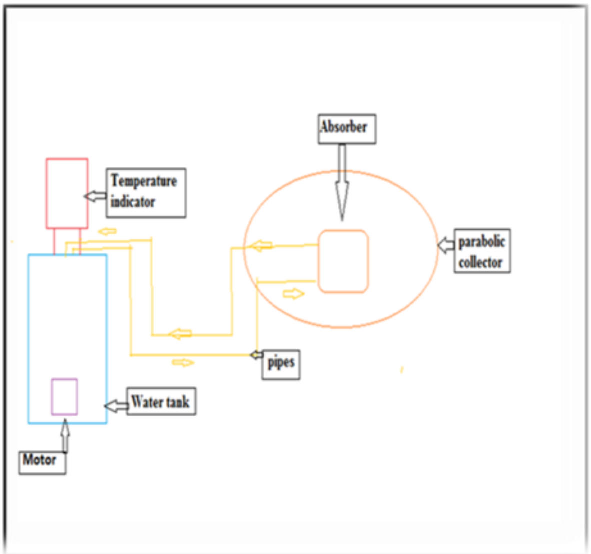

Fig.1 (a) Schematic diagram of Experimental setup (b) Photograph of the experimental setup

Fig. 1 shows the experimental set up of this project the experimental setup consists of a solar parabolic dish system, absorber, and heat transfer fluid as water which is circulated through the system from water tank. A pipe is used to carry the water from tank to the absorber tank and absorber tank is made up of aluminium. It is located in the focal point on the solar trace of parabolic dish.

When the sunlight rays are incident on the reflective surface they are reflected and conveyed to the surface of the absorber to heat the water. The parabolic dish made with highly reflective panels of stainless steel sheet, aluminium sheet and silver foil. The reflector cut into small shapes and fixed parabolic which can be turned conveniently. A manual tracking is provided to track the sun.

3. 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.

4. EXPERIMENTATION

The stepwise experimental procedure which is followed during the experiment is as follows:

1. Cleaning of the reflector surface and absorber to remove dust particles. The fresh water will be filled in the storage tank. The collector is exposed to the sun at least 30 min before start of the experiment.
2. Setting and tracking of the reflector towards the sun. The pump is started.

3. In each experiment, for 10 min duration, the water flow rate passing through the absorber is maintained constant rate.
4. Readings of the solar intensity and inlet, outlet temperatures of the working fluid from thermocouples are taken.
5. The readings are taken and noted down in a tabular form after every 10 min. Water is replaced after 1 hour.
6. The pump will be switched off and the whole set up is covered up. This procedure is repeated again for the next readings.

The same experimental procedure explained above will follow for all reflecting materials.

5. RESULTS AND DISCUSSION

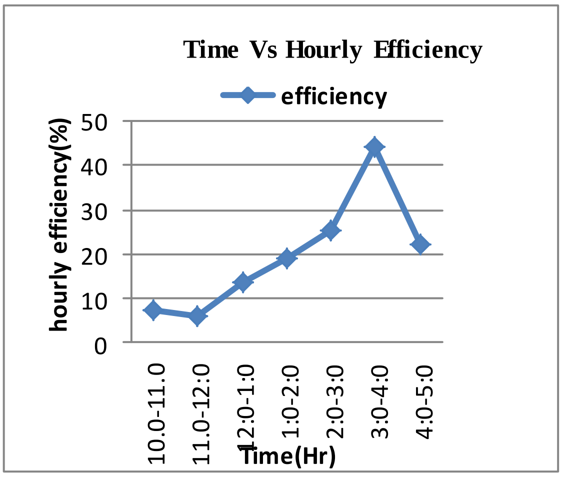

Chart-1 Variation in hourly efficiency with time stainless steel reflector

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 value 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.

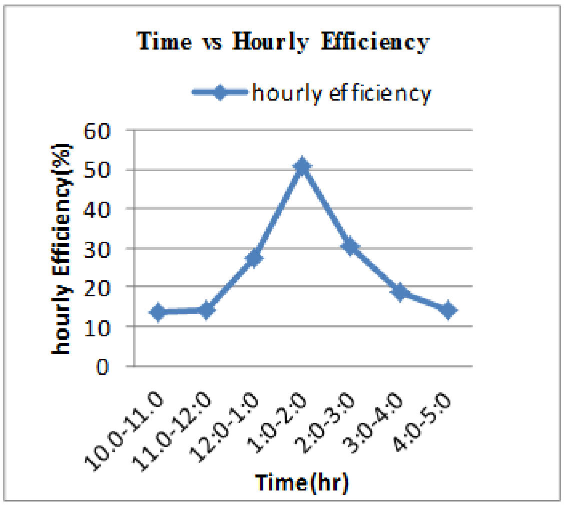

Chart-2 Variation in hourly efficiency with time aluminium sheet reflector

Graph shows diurnal variation in the hourly efficiency of aluminium 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.

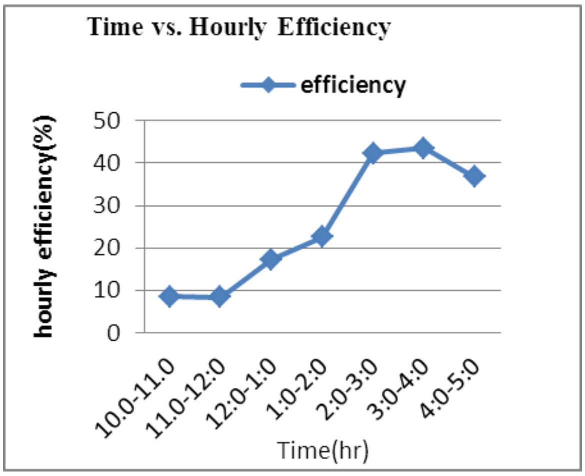

Chart-3 Variation in hourly efficiency with time silver foil reflector

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 upto 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.

Table-1 Result table for Overall Efficiency

Sr. no	Overall Efficiency (%)		
	Stainless Steel sheet	Silver Foil	Aluminium sheet
1	19.8	26.58	24.07

The above table shows the overall efficiencies of different reflecting materials.

6. CONCLUSION

In this work experimental and performance analysis of parabolic solar dish collector carried out with use stainless steel, silver foil and aluminium 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 overall thermal efficiency when silver foil is used as reflector is 26.89% which is highest amongst all the three cases.

$$\eta_{Silverfoil} > \eta_{Aluminium} > \eta_{Stainlesssteel}$$

Where,

$\eta_{Silverfoil}$ = Overall thermal efficiency of silver foil as reflecting material.

$\eta_{Aluminium}$ =Overall thermal efficiency of aluminium sheet as reflecting material

$\eta_{Stainlesssteel}$ = Overall thermal efficiency of stainless steel sheet as reflecting material.

By the comparative study of all three materials we found that the overall efficiency of silver foil is high, and having very good response to solar intensity as a reflecting material. The Reason behind this result is that silver foil has good reflectance as compared to other materials. As compared to the stainless steel and aluminium foil, the silver foil is cost effective and less material is required. So it is concluded that silver foil is economical to use as reflector for parabolic dish collector.

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