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Performance Analysis of a Low Cost Parabolic Solar Dish Collector

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Abstract: The excessive use of conventional resources and the problem associated with them has realised the need to harness the unconventional sources. Sun is the ultimate source of energy and expected to continuously supply solar energy up to millions of years. The great potential of solar energy has results the extensive research in this field. Solar energy can be harnessed by variety of ways. The most popular are solar water heating and photovoltaic application. The concentrating technology is best among all the existing techniques. Parabolic dish collector is concentrating Techniques possess minimum optical losses and maximum efficiency. In this paper performance of parabolic solar dish collector is studied. The application of dish concentrator on water heating is investigated. The intensity of solar radiation received to the earth with respect to time is measured. The Diurnal efficiency of parabolic dish collector over period of time is evaluated for different volume of receiver. The temperature of liquid present in receiver is also noted. It is found that the temperature and efficiency increases with increase in volume.

Keyword: Parabolic solar Collector, Solar energy, final temperature, Efficiency

I. INTRODUCTION

Solar water heating (SWH) converts the sunlight into useful heat. Solar water heating is the process of conversion of solar radiation into heat with the help of collector. Among the available technique to harness solar energy, concentrating collector is most promising one. Concentrating collectors are also known as focusing collectors. Higher temperature can be achieved with the help of concentrating collectors but they are limited due to higher cost associated with them. In focussing collectors a parabolic or Fresnel mirror is used. Sun rays are focussed on the focal point of the mirror by reflection from surface of reflector. A tube is placed along the focal line of the mirror and fluid is circulated to absorb the heat.

The focusing collectors have two types (i) Cylindrical parabolic concentrator, (ii)Paraboloids(Mirror arrays) First one is a medium range temperature concentrator. The reflectors [1] concentrate the sunlight on the absorber surface of receiver. Dubinsky et al [2] have studied a polar solar dish collector using petals as a reflecting material used in reflector. Wua et al. [3] have proposed combined thermoelectric and parabolic dish collector system. They have evaluated the overall performance of system is evaluated. Reddy et al. [4] have come up with the viability analysis of solar parabolic dish collector for Indian context. They find that parabolic dish collector is most efficient system for harnessing solar energy. Kumar et al. [5] have studied the effect of radiation heat transfer and convection heat transfer in the surface of reflector Arulkumaran et al. [6] have done analysis of production of steam in a non-tracking solar dish collector. The design and performance of system is evaluated. Sagade et al [7] have done experiment for low cost solar water heating useful for industry for Indian context. El Ouederni et al. [8] have 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. They found that temperature obtained at receiver centre is 400 °C and efficiency obtained in their experiment is 27%. Lifang Li et al. [9] have used the mirror reflective petals whose thin layers get the shape of parabola and ends are pulled by a cable. Ibrahim et al. [10] have developed model for heating of 40 litres capacity storage tank .The efficiency lies is in the range of 52%-56% in their observation. Obtained efficiency is more than expected.

Mohamed et al [11] investigated the solar dish collector with diameters 1.6 meters for water heating application. They used a reflecting metal with reflectivity 0.76 i.e. galvanised steel. Boiler is positioned in the focal point of the system. Maximum temperature obtained in their investigation is 800° C .Eswaramoorthy et al. [12] have conducted an experiment on small scale solar parabolic dish. Thermoelectric generators are used to generate electricity. The operating parameters involved in their study are receiver plate temperature, power output and conversion efficiency. It is concluded by them that the receiver plate temperature affects the power generation. Shiva Gorjian et al. [13] have studied the thermal performance analysis of a point focus solar steam generating system with parabolic concentrator. The receiver used is external type cylindrical

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receiver works under various climatic and operating conditions (including windy conditions) in Tehran round the year.

II. DESIGN SET-UP AND WORKING

2.1 Reflector

The reflector used in parabolic dish collector is consist of parabolic dish collector whose sole purpose is to concentrate the incoming solar radiation to the focal point with the help of reflecting surface coated with polished surface. [14] as shown in Fig 1.

2.2 Receiver

Receiver is the tank which store liquid inside and painted black for maximum absorptivity. It is placed at the focal point of the parabolic concentrator. Solar radiation is captured and converted into heat. There is convective loss associated with surrounding [15]. For minimizing the receiver losses, size is increased in turn to increase interception factor [16].

2.3 Follow-up of the sun

The follow-up of the sun is ensured by two commanded electric jacks. Two degree freedom mechanism is used to follow the sun .First electric jack is used to control hour angle and second is to control declination angle.

2.4 Radiation reading device

A solar radiation device Pyranometer is used to take the reading of solar intensity radiation from morning to evening.

2.5 Thermocouple

Two thermocouples is used to measure the initial temperature of water and the exit temperature after heating up of water due to solar radiation.

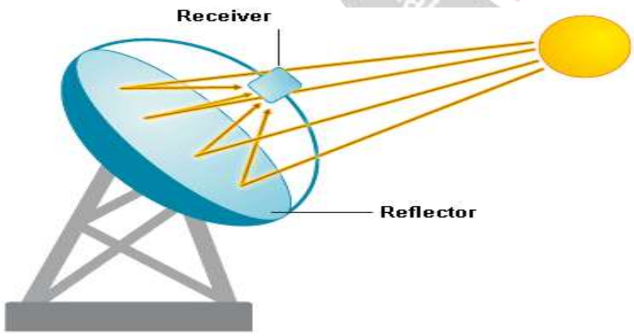

Fig 1: Systematic diagram of parabolic dish collector[17]

The parabolic dish solar concentrator system mainly consists of base support, concave dish frame, reflecting sheets, conversion unit and sun-tracking system as shown in Fig1.

The tracking system is dual axis tracking system with slew drivers. The first slew driver ensures rotation of the concentrator around the vertical axis through all possible azimuth angles while the second slew driver ensures rotation of the concentrator around the horizontal axis through all possible elevation angles. There are two systems to handle the entire dish with the converting unit. The present study implements the first technique. Special attention has been given to lower the cost of preparing reflective sheets as well as to minimize the weight of the dish.

The solar dish is formed into a paraboloidal shape by stamping them out from thin sheet thin aluminium coated with aluminium foil. The parabolic dish receives the incoming solar energy directly from the sun and concentrates on the focal point of parabolodial shape.

The parabolic concentrator surface is pasted with many small counters of polished reflectors throughout its shape.

These highly polished materials can reflect more than 90% of the sunlight that hits them increasing the efficiency of the dish by more than 20% compared to the parabolic trough collector. Highly polished surface are generally used instead of a single highly polished dish because they are relatively inexpensive, can be easily cleaned and last a long time in an extreme outdoor environment, making them an excellent choice for the reflective surface of a solar dish collector. Also individual polished surface can be easily changed if damaged.

III. METHODOLOGY OF EXPERIMENT

In this experiment the aperture area of concentrator .283 m^2 is used to heat a reservoir. The variation of temperature of liquid has been observed. The concentrator is arranged in direction of sun for more interception of sun light to receiver as shown in Fig 2.

Fig 2: Experimental setup for evaluating the performance of parabolic dish collector system

Concentrator consists of stainless steel sheet pasted with aluminium foil reflecting material. The parabolic shape has given via sheet metal work. The receiver is made of aluminium utensil popularly used for house hold purpose. The three temperature indicators are used to measure the temperature of concentrator, receiver and receiver without

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concentrator respectively. The variation of temperature of receiver is noted from morning to evening. Variation of solar intensity over the day is observed with the help of Pyranometer. The observation is varied due to dependencies on environmental condition like partially wheatear or clean sky.

IV. SOLAR THERMAL ANALYSIS OF PARABOLIC DISH COLLECTOR

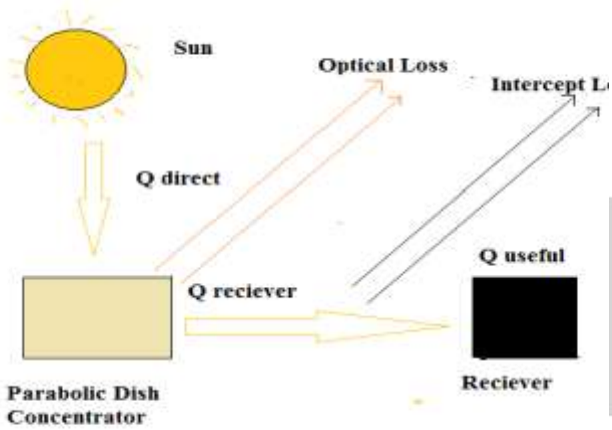

Fig 3: Schematic diagram representing the conversion of solar radiation to useful heat

1. Amount of solar radiation falling on the surface of concentrator directly is depend upon the irradiation I and area of the concentrator A conc

   $Q_{direct} = I\ A_{conc}$ (1)
2. Amount of solar radiation reflected to the surface of absorber tank depend upon the optical parameter i.e. called reflectivity ρ

   $Q_{receiver} = I\ A_{conc}\ \rho$ (2)
3. The useful energy gain on the receiver over the period of time due conversion of solar radiation

   $Q_{useful} = \frac{m * cp * (tf - ti)}{\tau}$ (3)

   where t_i is temperature of receiver tank at the start of period, t_f is the temperature of receiver tank after finish of period ,m is mass of liquid in tank,τ is time period and Cp is specific heat of liquid present in the receiver
4. Loss of radiation while transmission of radiation is the difference of radiation received to the receiver and the useful energy gain

   $Loss = Q_{useful} - Q_{direct}$ (4)

5. The efficiency of parabolic dish collector system can be given by

   $\eta pdc = Q\ useful / Q\ direct$ (5)

V. RESULT AND DISCUSSION

5.1 Variation of solar intensity over time period

It is found that in Fig 4 that with the few hour after starting of sunrise the solar intensity is very low and as the day proceed the intensity goes on increasing up to noon ,then decreases in the 2nd half of the day. The distribution is downward parabolic with peak at noon.

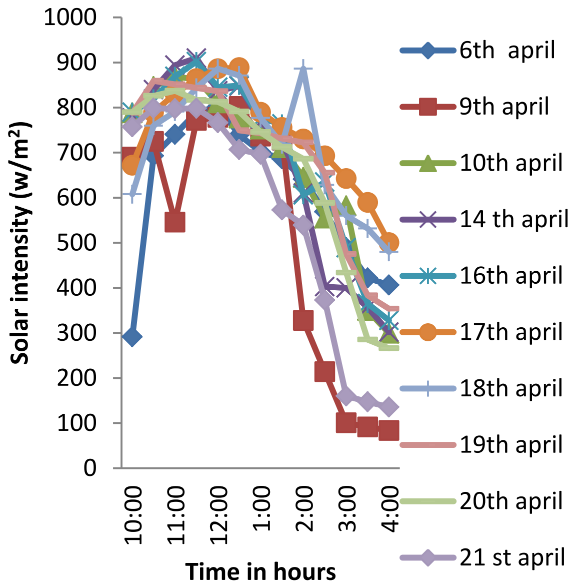

Fig 4: Variation of solar intensity with time in hours

The intensity of solar radiation is recorded in subsequent days .The minor variation are only due to the weather variation.

5.2 Variation of final temperature of water in reciever with time

The amount of water is varied in the reservior and final temperature of water present in reciever vary with time as shown in fig 5 & 6. It is observed that the temperature first increases and then it become stagnant and after that it decrease .The container with with greater volume has achieved higher temperature.

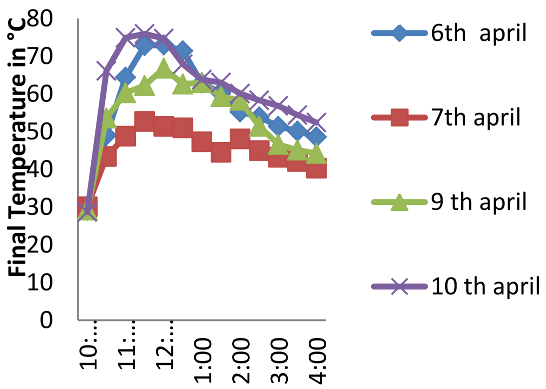

Fig 5 : Variation of final temperature of 0.5 liter water present in reciever with time in hours

The highest temperature of reciever obtained with 0.5 litre volume of water mass is 80 °C .However the maximum temperature obtained in case of 1 liter volume is 85 °C.

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The maximum temperature obtained is at afternoon. The temperature obtained without concentrator is 51 °C which is studied seperately. This indicate the effectiveness of the concentrating collector over direct heating. It is also noted in the course of experiment that the material of concentrator get heated due to ineffeciency of reflecting coating. It need to be rectified.

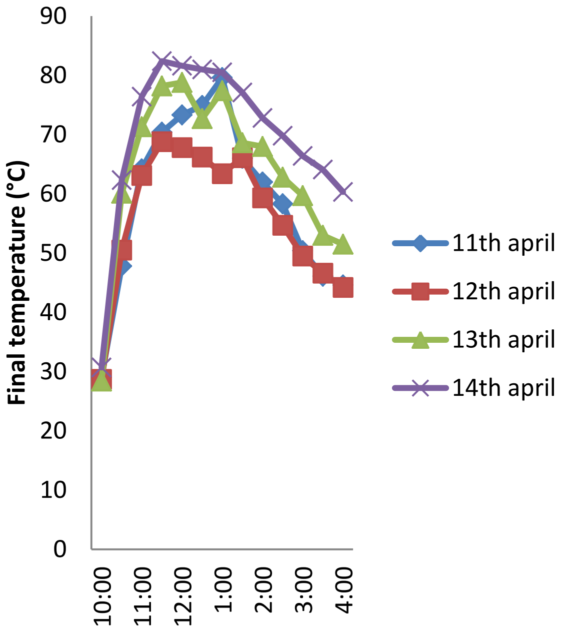

Fig 6 : Variation of final temperature of 1 liter water present in reciever with time in hours

5.3 Variation of efficiency over the day

It is found that with .5 litre volume, the maximum average efficiency obtained over the day is 47.7% depicted in Fig 7 and with 1 litre is 52.4% is illustrated in Fig 8.

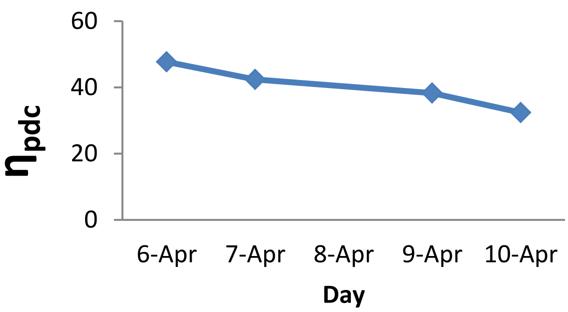

Fig 7: Variation of efficiency of .5 litre volume

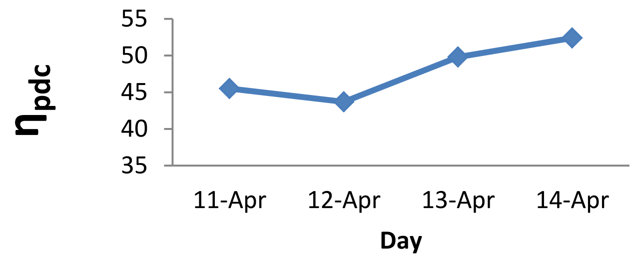

Fig 8: Variation of efficiency of 1 litre volume.

VI. CONCLUSION

The present paper has successfully study the diurnal temperature variation and efficiency of solar water heating system over a weak. The system volume also affects the performance of parabolic dish collector. It is found that as the volume of container increases the maximum temperature of receiver increases. The highest temperature obtained in 0.5 litre volume is 80 ˚C and 1 litre is 85 ˚C .The calculated diurnal efficiency of PDC is subjected to variation due to whether condition. However maximum efficiency is obtained with greater volume of liquid contained in receiver. The maximum efficiency obtained over a day is 52.4 % for 1 litre volume.

REFERENCE

[1] Gereffi, G., Dubay, K., Robinson, J., & Romero, Y. (2008). Concentrating solar power. *Clean Energy for the Grid*.

[2] Li, L., & Dubowsky, S. (2011). A new design approach for solar concentrating parabolic dish based on optimized flexible petals. *Mechanism and Machine Theory*, *46*(10), 1536-1548.

[3] Wu, S. Y., Xiao, L., Cao, Y., & Li, Y. R. (2010). A parabolic dish/AMTEC solar thermal power system and its performance evaluation. *Applied Energy*, *87*(2), 452-462.

[4] Reddy, K. S., & Veershetty, G. (2013). Viability analysis of solar parabolic dish stand-alone power plant for Indian conditions. *Applied energy*, *102*, 908-922.

[5] Reddy, K. S., & Kumar, N. S. (2008). Combined laminar natural convection and surface radiation heat transfer in a modified cavity receiver of solar parabolic dish. *International Journal of Thermal Sciences*, *47*(12), 1647-1657.

[6] Arulkumaran, M., & Christraj, W. (2012). Experimental Analysis of Non-Tracking Solar Parabolic Dish Concentrating System for Steam Generation. *Engineering Journal*, *16*(2), 53-60.

[7] Atul, S., & Shinde, N. (2012). Performance evaluation of parabolic dish type solar collector for industrial

 DOI : 10.18231/2454-9150.2018.0730 © 2018, IJREAM All Rights Reserved.

heating application. *International Journal of Energy Technology and Policy*, *8*(1), 80-93.

[8] El Ouederni, A. R., Salah, M. B., Askri, F., Nasrallah, M. B., & Aloui, F. (2009). Experimental study of a parabolic solar concentrator. *Revue des Energies Renouvelables*, *12*(3), 395-404.

[9] Li, L., & Dubowsky, S. (2011). A new design approach for solar concentrating parabolic dish based on optimized flexible petals. *Mechanism and Machine Theory*, *46*(10), 1536-1548.

[10] Mohammed, I. L. (2012). Design and development of a parabolic dish solar water heater. *Int J Eng Res Appl*, *2*(1), 822-30..

[11] Mohamed, F. M., Jassim, A. S., Mahmood, Y. H., & Ahmed, M. A. (2012). Design and study of portable solar dish concentrator. *International Journal of Recent Research and Review*, *3*, 52-59.

[12] Eswaramoorthy, M., Shanmugam, S., & Veerappan, A. R. (2013). Experimental study on solar parabolic dish thermoelectric generator. *International Journal of Energy Engineering*, *3*(3), 62.

[13] Eswaramoorthy, M., Shanmugam, S., & Veerappan, A. R. (2013). Experimental study on solar parabolic dish thermoelectric generator. *International Journal of Energy Engineering*, *3*(3), 62.

[14] Howard, D., & Harley, R. G. (2010, July). Modeling of dish-Stirling solar thermal power generation. In *Power and Energy Society General Meeting, 2010 IEEE* (pp. 1-7). IEEE.

[15] Sembiring, M., Napitupulu, F., Albar, A. F., & El Husein, M. N. (2007). A stainless steel parabolic. In *ICEE* (Vol. 1, pp. 45-9).

[16] Stine, W. B., & Diver, R. B. (1994). *A compendium of solar dish/Stirling technology* (No. SAND-93-7026). Sandia National Labs., Albuquerque, NM (United States).

[17] https://google images.com/

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