Steam Generation by Using Solar Dish Collector

Shubham Shinde[1], Rahul Shinde[1], Ashish Patil[1] , Chirag Desale[1]

[1]*Student, Department of Mechanical Engineering, P.V.P.I.T, Bavdhan, Pune, India-411021*

Abstract - *Solar parabolic dish is used for water heating and cooking application . Generally one parabolic dish is used and at its Focus parabolic receiver is kept..But, we used four parabolic dish mounted on a stand kept helical coil at focal point of all four dishes. The performance of the concentrator is experimentally investigated with water circulated as heat transfer fluid. The system is fabricated with highly reflective aluminium foil sheet .The result are encouraging to provide data for developing steam generation for rural application .The concentrated heat is absorbed by a copper tube which is made of coil in curved shape and the experimental results are taken on summer and cloud free days .the dish is equipped with tracking system and measurement of temperature is done. Temperature in the range of 120⁰C to 160⁰C is achieved.*

Key words *– Focal point, Temperature, Tracking System, efficiency, concentrator.*

1. INTRODUCTION

Unlike conventional power, solar produces no harmful emission that hurt environment it's a clean, renewable process that uses the most natural of all resources; the sun. solar energy can save own money from our energy bill each month if harnessed properly.

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

Experimental setup consist of four solar parabolic dish system, absorber, heat transfer fluid and tracking system.

When sunlight rays are incident on the reflective surface they are reflected and conveyed to the surface of the tube at the curve to heat the water and to take change phase .Thin Aluminium foil cut into the strips and pasted to the dish act as reflector. The focal point of four dishes are found out and helical coil is placed at the intersection of all four focal point.

Fig -1: Experimental Setup

Dual axis tracking system is used .Tracking System is helps to rotate the panel of dish from east to west and north to south. Solar tracking is procees of varying the angle of panel on which four dishes are mounted to take advantage of the full amount of solar energy. The panel is rotated perpendicular to the sun angle of incidence. It increases efficiency by 30-40%.

3. EXPERIMENTATION

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

1. Cleaning of reflector and remove the dust particles from the surface of reflector and absorber.

2. Tracking system connected to the panel and DC voltage supply to the motor.

3. Maintained the water flow rate.

4.Take the temperature reading at inlet of copper helical coil and outlet.

5. The reading are taken and noted down after every 1 Hr .

3.1 Expected Thermodynamic Performance of Parabolic Dish Concentrator:

The estimated useful energy for one cycle of the designed solar dish collector is given by

$q_{use} = \eta I_b A_a$

The efficiency range of most solar concentrators is 40% - 60%

Avg value of solar beam radiation at Pune in first quarter of 2014 is 714 W/m2

Hence $q_{use}=\dot{m}c_{pw}(T_w-T_a)=0.55*714*0.376=147.65$ W

For four dish total useful energy is $q_{use}=4 * q_{use}=592.19$ w

Useful energy is also given by

$$q_{use}= \dot{m}c_{pw}(T_w-T_a)= \eta I_b A_a$$

$$\dot{m} = \frac{\eta I_b*A_a}{C_{pw}*(T_w-T_a)}$$

= 0.00208 kg/sec

= 0.168 litre per minute

4. RESULTS

The tests were taken between 10 am to 4 pm in data were taken on each hour for 7 hours. The k type thermocouple with digital indicator used to measure temperature.

Table -1 Receiver temperature variation with Time

Time	*T_a ambient temperature ⁰C*	*T_g receiver temperature ⁰c*
10 am	32	70
11 am	33	85
12 pm	34	90
1 pm	34	110
2 pm	35	130
3 pm	34	115
4 pm	32	100

Table -2 Temperature variation with mass flow rate in kg/sec

Sr.No	*Mass flow rate Kg/sec*	*Temperature of receiver in ⁰c*
1	0.0014	130
2	0.0015	128
3	0.0016	126
4	0.0017	124
5	0.0018	122
6	0.0019	120
7	0.0020	118

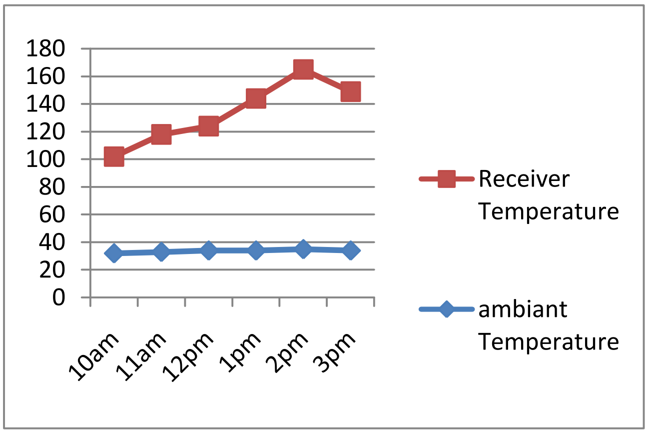

Chart -1: Receiver Temp Vs Time

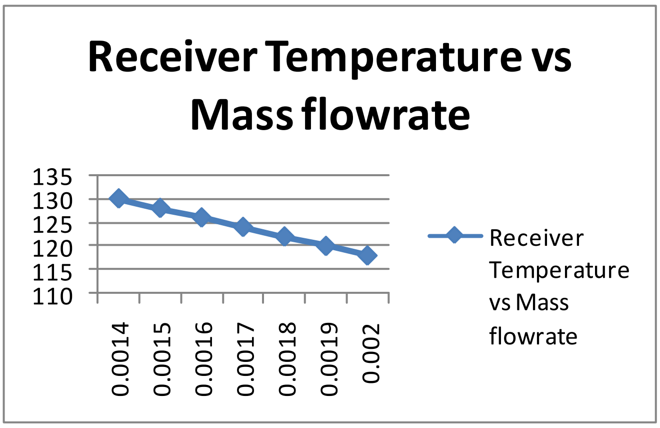

Chart -2: Receiver Temperature Vs Mass Flowrate

Graph shows the temperature of receiver is increased then the mass flow rate is decreased.

5. CONCLUSIONS

1. The experimentally calculated maximum temperature of receiver is 130⁰c which is actually equal to double of point focusing cavity receiver.

2. Heat loss from the coil receiver will decrease 20-30% compared to cavity receiver

3. Tracking system will increase the efficiency upto 30 to 40%

4. The system is more efficient for helical coil which is black coated

6. REFERENCES

[1] A.R. El Ouederni1, M. Ben Salah, F. Askri, M. Ben Nasrallah and F. Aloui "Experimental study of a parabolic solar concentrator", Revue des Energies Renouvelables Vol. 12 N°3 (2009), pp 395 – 404.

[2] Lifang Li, Steven Dubowsky "A new design approach for solar concentrating parabolic dish based on optimized flexible petals", Mechanism and Machine Theory 46(2011) pp 1536-1548.

[3] Ibrahim Ladan Mohammed "Design and development of a parabolic dish solar water heater" International Journal of Engineering Research and Applications (IJERA), Vol. 2, Issue 1, Jan-Feb 2012, pp. 822-830.

[4] Fareed. M. Mohamed, Auatf.S.Jassim, Yaseen. H. Mahmood Mohamad A.K.Ahmed "Design and Study of Portable Solar Dish Concentrator Fareed" International Journal of Recent Research and Review, Vol. III, September 2012, pp 52-61

[5] M.Eswaramoorthy1, S.Shanmugam2, A R. Veerappan "Experimental Study on Solar Parabolic Dish Thermoelectric Generator", International Journal of Energy Engineering (IJEE) Jun. 2013, Vol. 3 Iss. 3, PP. 62-66.

[6] Ibrahim Ladan Mohammed "Design and Development of a Parabolic Dish Solar Thermal Cooker" International Journal of Engineering Research and Applications (IJERA) Vol. 3, Issue 4, Jul-Aug 2013, pp.1179-1186.

[7] Avadhesh Yadav, Manoj Kumar, Balram "Experimental Study and Analysis of Parabolic trough Collector with Various Reflectors" International Journal of Mathematical, Computational, Physical and Quantum Engineering Vol:7 No:12, 2013 pp1161-1165.