International Journal of Analytical, Experimental and Finite Element Analysis (IJAEFEA), Issue. 3, Vol. 4, Sept 2017.
e-ISSN: 2394-5141, p-ISSN: 2394-5133, pp 45-47
DOI: 10.26706/IJAEFEA.3.4.20170803

An Experimental Investigation of Solar Assisted Air Heating for Solid Desiccant Regeneration using Parabolic trough Solar Concentrator

K. S. Rambhad[1],
kishorsrambhad@gmail.com
[1]Research Scholar,

Dr. P. V. Walke[2],
[2]Professor

Department of Mechanical Engineering,
G. H. Raisoni College of Engineering, Nagpur- 440016, India

Abstract-- ***A solar assisted air heating system using parabolic trough solar collector (PTSC) with and without aluminum coil was investigated experimentally. In this experimental study, the reflected solar radiations were directed on absorber tube which was managed at focal length of the parabolic trough. Experimental investigation was comprised in two cases. For case 1, experimentation was carried out without aluminum coil and for case 2, aluminum coil was placed inside evacuated tube to improve the performance of PTSC. In this experimental study, working fluid was an air which collects the heat from evacuated absorber tube. It was observed that, for aluminum coil maximum temperature was 82ºC, which 11% more than case1, also efficiency by using aluminum coil was 7% more than case 1. Hot air obtained from parabolic trough solar concentrator was used to regenerate solid desiccant wheel.***

Index terms: *Aluminum coil, evacuated tube, mirror reflector, parabolic trough solar collector.*

I. Introduction

Depletion of fossil fuel and global warming problem is responsible for taking notice of society to make use of clean and naturally available energy sources. Renewable energy sources are like solar energy is sustainable by producing no green house gas emissions and will be available forever, so they found to be the most suitable energy sources for the future. Solar energy is one of the oldest energy source used ever and is widely used by giving solutions in many applications, from industrial hot water supply to electricity production [1–4], Greece has high solar irradiation level [5,6]. More specifically, concentrated solar collectors are able to produce high temperatures (> 400°C) with high thermal performance. This is the fact that makes them a feasible and promising technology for solar desalination, solar chemistry applications, solar cooling, solar-hydrogen production and of course for Concentrated Solar Plants (CSP) [7]. The main solar technologies for electricity production are Linear Fresnel collectors, parabolic dish combined with a Stirling engine, parabolic trough collectors and solar tower [8,9]. Parabolic trough collector covers 90% of the total CSP systems [10], this technology is quite mature among all concentrated technology; it leads to light structure systems and is applied since decades [11]. Now a days, many commercial CSP systems are operating in various countries like U.S.A.[12], Algeria [13,14] and Spain [15]. The basic parts of a PTC are an evacuated tube and a linear parabolic reflector. The reflector is made by bending a reflecting material into a parabolic shape and the evacuated tube is located in the focus line of this parabola. The main idea of this technology is the reflection of the solar beam radiation from the parabolic reflector towards to the evacuated tube in order to heat the working fluid. The general efficiency improvements and the cost reduction of PTC systems are essential factors for the further development of CSP systems worldwide [9,16]. Thus, many researchers have been working in this field trying new ideas and optimizing the existing collectors [17,18].

II. Experimental Setup

The test section of solar air collector is based on evacuated tube and mirror reflector. This system consists of parabolic trough solar collector with reflector mirror. The length of aperture of collector and absorber tube was taken as 1.6 m. The diameter of the outer glass tube and absorber tube used 0.058 m and 0.047 m respectively. In this experimental setup, reflector mirror was used for reflecting solar radiation. A blower with power of 1 HP was used to blow the air in the solar air collector. Air flow rate was controlled by a speed regulator. To increase the temperature of outlet air, a helical coil of aluminum was placed inside the evacuated tube.

In Experimental setup, parabolic trough collector with an aperture area 2.56 m^2, focal length 0.4 m and rim angle 90^o was used for solar air heating. The flow rate of the air was adjusted at the start of experimental work. The experimental data is recorded at an interval of 1hour (09:00hrs–17:00hrs) in the month of November 2015. Experimental setup of parabolic trough collector is shown in figure1.

Figure 1. Experimental set up of parabolic trough collector

The above experimental set up consists of parabolic trough, reflector glass mirror, absorber tubes, glass envelope and aluminum coil. The fabrication of the collector takes the maximum effort for the whole efficiency of the object depends on the capability of the reflector to focus the radiation reflecting from the collector surface. For the development of the collector, first the size of the parabola is determined then its focal point position is evaluated which is accessed from the curve mathematical relation. CAD model of parabolic collector is shown in figure 2.

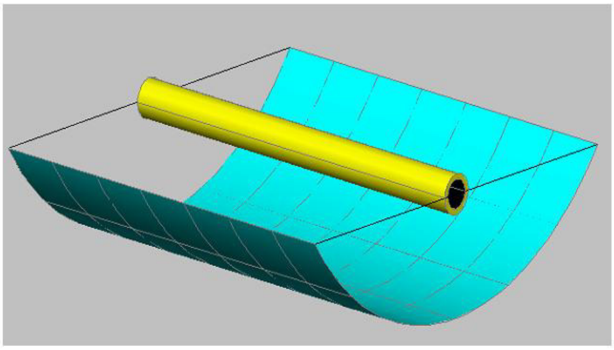

Figure 2. CAD model of parabolic trough collector

III. Results and Discussion

Parabolic trough collector was developed and used for air heating by manual tracking. Using this parabolic trough collector, thermal performance at low flow rate was found for two cases.

In this experimental investigation, the main concern is the heating of air. The experimental data is collected on the clear sunny days. The results are taken in the month of November of 2015 for case 1 and December for case 2 during which ambient temperature and solar intensity remained in the range of 29-37°C and 440-835 W/m2. The experiment was carried out from 09:00 hr to 17:00 hour and data is recorded in the interval of 1 hr. The collector was exposed to solar radiation for an hour before the start of reading. Two cases have been taken for same different flow rate.

Case 1: Performance of parabolic trough collector without aluminum coil

From the experimentation it has been observed that the temperature of outlet air of evacuated tube solar air collector steadily increases as shown in figure 3. The maximum intensity of solar radiation is achieved a little later after solar noon. The temperature of outlet air keeps on increasing at a higher rate than ambient temperature due to the high heat capacity of working fluid in the setup. The working fluid achieves its maximum temperature at around 13.00 - 14:00 hours, and stays nearly as hot till 16:00 hours. The maximum temperature difference between inlet and outlet air is 39°C at 14:00 hours and the maximum temperature of outlet air is 74°C. From 09.00 hours to 10.00 hours, efficiency increases rapidly because the variation in temperature difference is faster and intensity of radiation is very low. From 11.00 hours to 16.00 hours, efficiency increases slowly because of the variation in temperature difference being little faster than that in the intensity of radiations. From 16.00 hours to 17.00 hours efficiency increases rapidly because the variation in temperature difference being little slower than the intensity of radiation. The efficiency of parabolic trough collector was found to be 15.12%.

Case 2: Performance of parabolic trough collector with aluminum coil

An aluminum wire of 2 mm diameter is formed into a coil and inserted inside the absorber tube. The diameter of aluminum coil was maintained such that the coil was in contact with the inner surface of absorber tube. The maximum temperature difference between inlet and outlet air is 47°C at 14:00 hours and the maximum temperature of outlet air is 82°C and efficiency of the parabolic trough collector with aluminum coil is obtained 16.08% more than without coil i.e. case 1. The trend of the observations was obtained same as that of case 1, but in case 2 temperature differences was observed more.

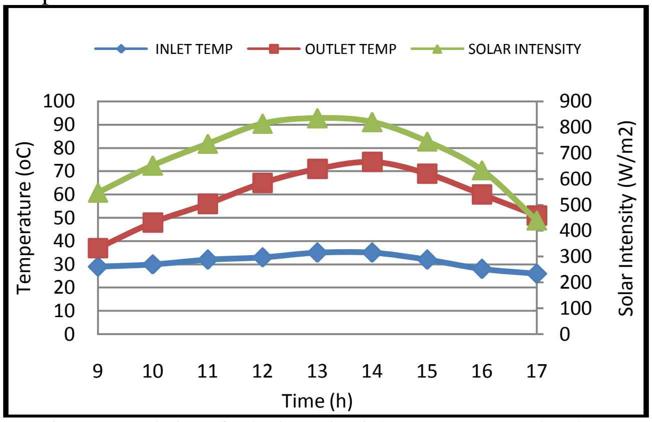

Figure 3. Variation of solar intensity, inlet temperature and outlet temperature with time for air flow rate of 24.41 kg/h

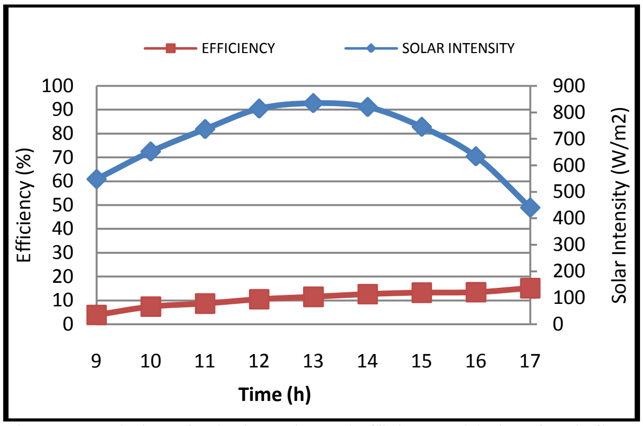

Figure 4. Variation of solar intensity and efficiency with time for air flow rate of 24.41 kg/h

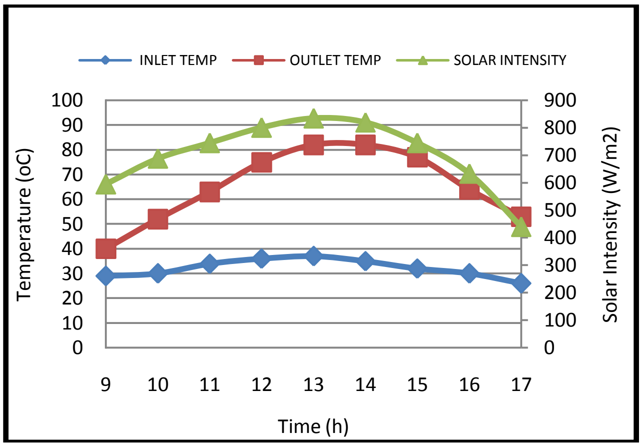

Figure 5. Variation of solar intensity, inlet temperature and outlet temperature with time for air flow rate of 24.41 kg/h

e-ISSN: 2394-5141, p-ISSN: 2394-5133, pp 45-47
DOI: 10.26706/IJAEFEA.3.4.20170803

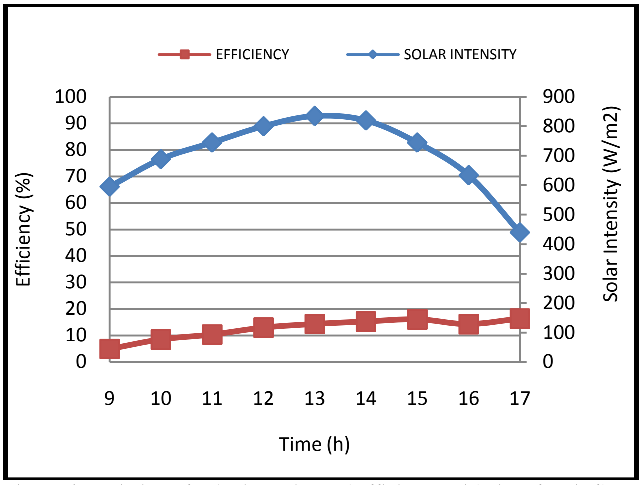

Figure 6. Variation of solar intensity and efficiency with time for air flow rate of 24.41 kg/h

IV. Conclusion

In this paper, the thermal performance of mirror reflector for parabolic trough collector has been presented using manual tracking. In this performance test mirror reflector without aluminum coil and with aluminum coil at low air flow rate have been used which can be used for room heating, process heating, desiccant reactivation etc. The air flow rate of 24.41 kg/h was selected for the analysis for both cases. For both cases temperature difference and collector efficiency were recorded. The thermal efficiency of collector obtained 15.12% and 16.08% for case 1 and case 2 respectively. It has been observed from this performance test that there is increase in temperature difference and collector efficiency when aluminum coil is used.

References

[1] K. Nithyanandam, R. Pitchumani, Optimization of an encapsulated phase change material thermal energy storage system, Solar Energy 107(2014)770–788.

[2] N. S. Suresh, N. C. Thirumalai, Badri S. Rao, M. A. Ramaswamy, Methodology for sizing the solar field for parabolic trough technology with thermal storage and hybridization, Solar Energy 110(2014)247–259.

[3] Gur Mittelman, Michael Epstein, Anovel power block for CSP systems, Solar Energy 84(10)(2010)1761–1771.

[4] A. Fernández-García, E. Zarza, L. Valenzuela, M. Pérez, Parabolic-trough solar collectors and the its applications, Renewable and Sustainable Energy Reviews 14(2010) 1695–1721.

[5] K. Zabara, Estimation of the global solar radiation in Greece, Solar Wind Technology 3(4)(1986)267–272.

[6] D. A. Kouremenos, K. A. Antonopoulos, E. S. Domazakis, Solar radiation correlations for the Athens, Greece, area, Solar Energy. 35(3)(1985)259–269.

[7] D. Kruger, Y. Pandian, Parabolic trough collector testing in the frame of the REACt project, Desalination 220(1–3)(2008)612–618.

[8] R. Grena, Optical simulation of a parabolic solar trough collector, International Journal of Sustainable Energy 29(1)(2010)19–36.

[9] H. Price, E. Lópfert, D. Kearney, E. Zarza, G. Cohen, R. Gee, Advances in parabolic trough solar power technology, Journal of Solar Energy Engineering 124(2002)109–125.

[10] Marco Binotti, Guangdong Zhu, Allison Gray, Giampaolo Manzolini, Paolo Silva, Geometric analysis of three-dimensional effects of parabolic trough collectors, Solar Energy 88(2013)88–96.

[11] J. A. Clark, Ananalysis of the technical and economic performance of a parabolic trough concentrator for solar industrial process heat application, International Journal Heat Mass Transf. 25(9)(1982)1427–1438.

[12] S. Al-Soud Mohammed, S. Hrayshat Eyad, A 50 MW concentrating solar power plant for Jordan, Journal of Cleaner production 17(2009)625–635.

[13] N. ElGharbi, H. Derbal, S. Bouaichaoui, N. Said, A comparative study between parabolic trough collector and linear Fresnel reflector technologies, Energy Proceeding 6(2011)565–572.

[14] T. Boukelia, M. S. Mecibah, Parabolic trough solar thermal power plant: potential, and projects development in Algeria, Renewable and Sustainable Energy Reviews 21 (2013)288–297.

[15] W. Grasse, Solar PACES Annual Report, DLR, Germany, 1995.

[16] Malika Ouagued, Abdallah Khellaf, Larbi Loukarfi, Estimation of the temperature, heat gain and heat loss by solar parabolic trough collector under Algerian climate using different thermal oils, Energy Conversion and Management 75(2013)191–201.

[17] Ze-Dong Cheng, Ya-Ling He, Bao-Cun Du, Kun Wang, Qi Liang, Geometric optimization on optical performance of parabolic trough solar collector systems using particle swarm optimization algorithm, Applied Energy 148(2015)282–293.

[18] A. de Risi, M. Milanese, D. Laforgia, Modelling and optimization of transparent parabolic trough collector based on gas-phase nanofluids, Renewable Energy 58(2013)134–13