Analysing Efficiency of Solar Collector using ETC Absorber Tube

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Abstract – *This paper centers around the analyzing efficiency of solar collector using ETC absorber tube. India's total peak electricity demand in 2017-18 was 164 Gw and is expected to be 235 Gw by 2021-22. Solar energy will play an important role in the future. It is not an easy task to provide energy need of 1.2 billion populations. Lots of Different comes on the way like under development infrastructure, conventional technologies etc. There is an urgent need to Modernise non-conventional source of energy. During experiment source of enegy. During experiment it was found that ordinary collector lies in the range of 9% to 21% and it is increased upto 10% to 23.4% with ETC absorber tube.*

***Key Words*:** Tubelar, Collector, Concentrating, Absorber, thermal efficiency.

1. INTRODUCTION

India is enriched with a very vast resources of solar energy. Major part of the country has good sunshine of around 225-250 days, with an intensity of 4-6.5 KW/m^2-day of direct normal irradiance (DNI). When incident solar radiation is received and transferred as heat to utilize for various useful works, is called solar thermal energy. It is very easy for anyone to understand the importance of heat from solar energy in our day to day life and significance of availability of fuel in the future. Depending on the latest teclnologies output temperature of the thermal energy can be achieved up to 3000^{o}C.This output opens up larger area of applications like, cocking, water/ air heating, drying of agricultural s food products and water distillation. Nowadays designing of energy efficient apartment / building based on solar energy concept is an important emerging trend. In India the first Solar Thermal Power Plant of 50kW capacity has been installed by MNES in parabolic trough collector type technology at Gwalpahari, Gurgaon, which was commissioned in 1989. A Solar Thermal Power Plant of 140MW at Mathania in Rajasthan, has been proposed and sanctioned by the Government in Rajasthan. Presently total installed solar thermal power generation capacity in India is about 0.5 GW and India occupies fourth position is the world.

Solar collectors are used for energy collection. It collects the radiation and transfers the energy to a fluid passing through it. Solar collectors can be classified on the basis of five characteristics:

a) The collector type
b) The concentrating or non-concentrating characteristic of the system
c) The motion of the system
d) The absorber type
e) The range of the temperature delivered.

The one single axis tracking system is a device which allow the solar system to follow the sun with one axis of rotation either along the north-south direction or east-west direction. The two axis tracking system has two degrees of freedom that act as axis of rotation. The axis are perpendicular to each other. Three types of absorbers are used

I. Tubular
II. Flat
III. Point

Tubular and point absorbers are used in concentrating systems, while flat absorbers are used in the panel which uses sun beams.

Non-focussing type or Non-concentrating type: -

This type of collectors can collect both types of radiation: diffuses as well as direct radiations.

In non-focussing type of collectors area. This type of collector is generally used for low temperature needs. These are of two types:

(a) Evacuated tube solar collector
(b) Flat plate solar collector.

Focussing type or concentrating type:-

This type of collectors concentrates the solar energy incident over a large surface area on to a smaller surface area.

2. LITERATURE

Clark J.A. [5] [1982] analyzed the technical and economic performance of a parabolic trough concentrator for solar industrial process heat application. The factors considered in this study were reflectivity of mirror system, incident angle modifier, absorptivity–transmissivity product of receiver tube and receiver tube misalignment. As per economic point of view longer periods of investment increases the economic competiveness of solar concentrator for industrial process heat application.

Hamad F.A.W. [8] [1988] conducted an experimental study for determining the performance of a cylindrical parabolic concentrating collector with a novel design of the absorber. The experiments have been performed during winter and summer at Basrah, Iraq. It has been found that the concentrator performance depends mainly on water mass flow rate, and there is no significant change when the water mass flow rate becomes more than 10kg/h. This paper concluded the following points: The collector performance varied from 26 to 62% while the water mass flow rate is varied from 2 to 34 kg/h. The concentrator can supply 20kg/h of hot water with a temperature rise of 15°C.

Kalogirou [10] et al. [1994] investigated the design and performance characteristics of a parabolic trough solar collector system. They optimized the aperture area, rim angle and receiver diameter of a parabolic trough collector. It was observed that, with a 90° rim angle, the mean focus to reflector distance and the reflected beam spread was minimized.

Brogren Maria [4] et al. [2004] used aluminium polymer laminated steel reflector and tested its optical properties, durability and reflector performance in solar thermal and photovolatic system. The optical properties of the reflector material were investigated using spectrophotometer and scatterometry. Before ageing, specular reflectance value was 77% and after 2000 h in damp heat, specular solar reflectance had decreased to 42%. This decrease was found to be due to degradation of the polyethylene terephthalate layer, caused by UV radiation and high temperature.

Arasu and Sornakumar [2] [2007] designed and tested the fiberglass reinforced parabolic trough for parabolic trough solar collector. It was tested under a load corresponding to force applied by a blowing wind with 34 m/s. They analyzed that the deflection at the center of the parabola was only 0.95 mm with wind drag force load of 72 kg, which is considered adequate.

Yashavant [12] et al. [2011] numerically investigated the performance of parabolic trough receiver with outer vacuum shell and compared with non-evacuated shell receiver. The vacuum shell configuration performs better than the non-evacuated tube even without a selective coating and is significantly better with selective coating.

Folaranmi J [6] [2009] reported the designed, constructed and testing of a parabolic solar steam generator works on solar energy and made concentrating collector, heat from the sun was concentrated on a black absorber located at the focus point of the reflector in which water is heated to a very high temperature to form steam. It also describes the sun tracking system unit by manual tilting of the lever at the base of the parabolic dish to capture solar energy. The whole arrangement is mounted on a hinged frame supported with a slotted lever for tilting the parabolic dish reflector to different angles so that the sun is always directed to the collector at different period of the day. On the average sunny and cloud free days, the test results gave high temperature above 200°C.

Brooks, M.J [3] et al. [2006] conducted experiment to measure and testing the performance of components of parabolic trough solar collector and development in a solar energy research programme. Low-temperature testing was performed at Mangosuthu Technikon's STAR lab facility using water as the working fluid. Both an evacuated glass shielded receiver and an unshielded receiver were tested, with which peak thermal efficiencies of 53.8% and 55.2% were obtained respectively. The glass-shielded element offered superior performance at the maximum test temperature, experiment contain also tracking system. Pumping system provided for feed control quantity of fluid. In this study only low-temperature testing was conducted with receiver inlet temperatures from 20°C to 85°C.

C.A. Arancibia-Bulnes and S.A. Cuevas [1] [2004] Modeling a radiation field in a parabolic trough solar photo catalytic reactor and calculate the distribution of absorbed radiation inside a solar photocatalytic reactor. The reactor configuration is that of a glass tube illuminated by a parabolic trough collector, where the catalyst consists of titanium dioxide micro-particles suspended in water. The calculations are made within the framework of the P1 approximation, which allows solving analytically the radiative transfer equations. The effect of catalyst concentration on the degradation of pollutants, by means of a general kinetic model and evaluate optical effects on the kinetics of chemical reactions carried out in these systems.

M. Halil [9] [1984] conducted experiments in which one-dimensional heat transfer model for the thermal analysis of the receiver subsystem was presented to reducing the optical errors. It is also useful for analysis the geometry of collector. It was shown that this model could be used to calculate a heat-loss parameter of receiver surface area to characterize the thermal behaviour of the receiver. It was shown that the presented thermal analysis could be used to size the annulus gap size. The method developed in which can be used in a comprehensive design and optimization method.

Garcıa A. Fernandez [7] et al. [2010] presents paper in which an overview of the parabolic trough collectors that have been built and the prototypes currently under development. It also presents a survey of solar system to supply thermal energy up to 400^0C, which is especially for steam power cycles for electricity generation. First commercial collectors used in U.S. Government's Sandia National Laboratories and Honeywell International Inc. Both collectors were quite similar in concept and were prepared to work at temperatures below 250 ^{0}C. They studies Luz collectors, Euro Trough collector and discuss their application in the field of Steam production for sterilization, Dairy, Steam production for silk printing, Steam production for pharmaceutical chemicals, Cold generation, Refrigeration in isolated areas etc.

Sangotayo. E.O. [11]et al. [2012] reported numerical investigation on the enhancement of thermal performance of solar air heater having cylindrical parabolic trough solar collector with twisted tape in different weather conditions. Two dimensional fully developed fluid flow and heat transfer is studied. Instantaneous efficiency is finding 47.4% at optimal design parameters of 1.3m length and mass flow rate 0.036kg/s. At high value of Nusselt number, heat transfer coefficient is increased. Twisted tape in the absorber tube increase the thermal performance.

2.1 Problem formulation:

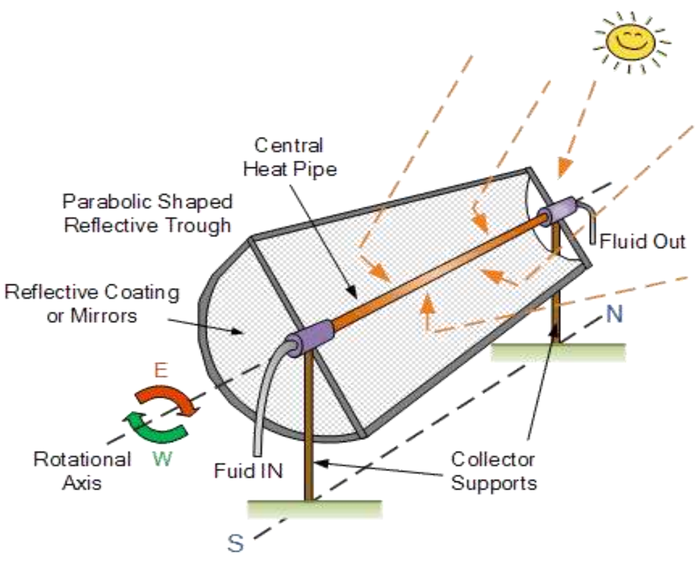
Solar heater losses too much thermal heat and because of this it becomes less efficient. Several researchers have suggested to use packed bed for the improvement of performance of solar air heater. Improvement of efficiency and reliability of wide range of energy system depends on energy storage and it plays an important role in conserving the energy. Energy storage improvement can reduce the gap between energy supply and energy demand.

2.2 Methodology

Parabolic trough solar collector is installed initially. After that it is tested at KIET, Ghaziabad from morning to evening and the results are analysed to enhance its performance using different absorbers.

Parabolic trough solar collector:-

Parabolic trough solar collector uses aluminium or mirror foil sheet in the shape of a parabolic cylinder to concentrate and reflect sun radiation towards a receiver fixed at the focus line of the parabolic cylinder.



. **Fig. Schematic diagram of Parabolic Trough Concentrator**

3. Result and Discussion

Table 3.1: Measured data with copper absorber tube painted black at air flow rate i.e. 28.5 kg/hr

Time (hrs)	Solar radiation (W/m^2)	Ambient Temp. (^oC)	Inlet air Temp. (^oC)	Outlet air Temp. (^oC)	Temperature difference (^oC)	Thermal Efficiency (%)
1000	630	33	34.1	40.6	6.5	9.9
1100	760	36	37.3	46.3	9	11.37
1200	920	40	43.5	58.5	15	15.65
1300	900	42	45.5	62.3	16.8	17.92
1400	820	43	43.1	61.8	18.7	21.89
1500	700	41	41.3	55.5	14.2	19.47
1600	540	39	40.0	50.2	10.2	18.13
1700	320	36	36.4	42.5	6.1	18.3

Table 3.1 Shows the reading of inlet air temperature and outlet air temperature after the end of absorber tube made of copper and painted black externally. This setup will increase the maximum air temperature about 18^oC and this is slightly higher than that of using copper tube only but less than that of when absorber tube filled with pebbles.

Table 3.2: Measured data with Evacuated Tube at air flow rate i.e. 28.5kg/hr

Time (hrs)	Solar radiation (W/m^2)	Ambient Temp. (^oC)	Inlet air Temp. (^oC)	Outlet air Temp. (^oC)	Temperature difference (^oC)	Thermal Efficiency (%)
1000	660	33	33.1	40.2	7.1	10.32
1100	780	36	38.2	48.0	9.8	12.06
1200	940	41	42.5	59.2	16.7	17.05
1300	920	42	45.8	62.4	17.6	18.36
1400	800	43	43.9	63.4	19.5	23.39
1500	680	40	41.8	55.8	14	19.76
1600	540	38	40.3	50.8	10.5	18.66
1700	340	33	35.4	42.4	7	19.76

In this arrangement maximum air temperature rise is about 20^0 C and it is much higher than the data obtained by other arrangements.

4. Conclusions

- By using ETC tube efficiency increases by around 8%
- Highest temperature difference is 23.390 C at an air flow rate of 28.5 kg/hr.
- At an air flow rate of 28.5 kg/hr, the efficiency of ordinary collector lies in the range of 9% to 21% during the day and it is increased up to 10% to 23.4% with ETC absorber tube.

REFERENCES

[1] Arancibia-Bulnes C.A., and Cuevas S.A., 2004 "Modeling of the radiation field in a parabolic trough solar photocatalytic reactor. Mexico".

[2] Arasu A. Valan and Sornakumar T., 2007, "Design manufacturing and testing of fiber glass reinforced parabola trough for parabolic trough solar collectors", Solar Energy, 81, 1273-1279.

[3] Brooks, M.J., Mills, I and Harms, T.M., 2006, "Performance of a parabolic trough solar collector. Journal of Energy in Southern Africa", Vol-17, page 71-80 Southern Africa.

[4] Brogren M., Helgesson A., Karlsson B., Nilsson J., and Roos A., 2004, "Optical properties and system aspects of a new aluminum/polymer/laminated steel reflector for a solar concentrator", Solar Energy Materials and Solar Cells, 82, 387-412.

[5] Clark J.A., 1982, "An analysis of the technical and economic performance of a parabolic trough concentrator for solar industrial process heat application", International journal heat mass transfer, 25, 1427-1438.

[6] FOLARANMI, J., 2009 "Design, Construction and Testing of a Parabolic Solar Steam Generator", Journal of Practices and Technologies ISSN 1583-1078, Vol-14, page 115-133, Leonardo.

[7] Garcıa A. F., Zarza E., Valenzuela L. and Perez M., 2010 "examination of Parabolic-trough solar collectors and their applications. Vol-14, page 1665-1721, Spain.

[8] Hamad F.A.W., 1988, "The performance of a cylindrical parabolic concentrator", Energy Conversion Management, 28, 251-256.

[9] Halil M. G. and Richard B. B., 1984 "Optical and thermal analysis of parabolic trough solar collectors for technically less developed countries" Technical report, USAID Project Grant No. 386-0465, Texas.

[10] Kalogirou S.A., 2009, "Solar Energy Engineering: Processes and systems", Ist ed. Academic USA, (2009).

[11] Sangotayo E.O., Adekojo W.M. and Alamu J.O., 2012, "Examination of Parametric Study of Thermal Performance of Cylindrical Parabolic Trough Solar Collector in Ogbomoso Environs" , The Pacific Journal of Science and Technology, Vol-13, page 159-166.

[12] Yashavant J., Daniel P., and Das A. K., 2011, "Numerical investigation of parabolic trough receiver with outer vacuum shell", Solar Energy, 85, 1910-1914.