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Fabrication and Performance Analysis of Hybrid Solar Air Heater

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***Abstract*— The electricity and heat produced simultaneously in a Photovoltaic thermal (PV/T) system from solar energy is about 60-70% efficient. The traditional Photovoltaic (PV) system conversion of electricity from solar energy is only about 6-15% efficient, where as 85% of the incoming solar energy is either reflected or absorbed as heat energy, which are cooled by air coolant to utilize the all incoming solar energy on system. The main novelty in this project work is combination two systems as Photovoltaic Thermal and solar air heating system. The photovoltaic system wasted heat energy is absorbed in cold air. The preheating air from Photovoltaic thermal system is allowed to pass through the air heater, where the hot is much enhanced by the solar radiation and improves the efficiency of air heating system. There are analyses to configuration on with fins and baffles and with fins and without baffles to improve on thermal efficiency was studied.**

Keywords—Single pass solar air heater, Fins and Baffles, ans Photovoltaiv cells.

I. INTRODUCTION

Solar energy is a clean energy which has the potential to meet a significant proportion of the worlds energy needs. It can be broadly classified into two systems, thermal energy system which converts solar energy into electrical energy. The vital components in solar energy systems are the solar collector. In the thermal system, the collector is heated by the sun and heat is then transferred to a working fluid. In the Photovoltaic system, the collector is comprised of Photovoltaic cells which convert the solar radiation into electrical energy. The term Photovoltaic Thermal (PV/T) refers to solar thermal collector that uses PV cells as an integral part of the absorber plate. The system generates both thermal and electrical energy simultaneously.

The number of the Photovoltaic cells in the system can be adjusted according to the local load demands. A number of simulation as well as experimental studies have been reported on the photovoltaic- thermal (PV/T) system. The concept of PV/T collector using water or air as the heat removal fluid by Kern and Russel [1]. Suggested an extension of the Hotter – Willier model for the analysis of the (PV/T) system by Florschuetz et al.[2] and presented numerical methods predicting the performance of liquid and air PV/T flat plate collectors by Raguraman et al.[3]. Performed computer simulation on air type hybrid system by Cox and Raguraman [4]. Reported the effect of air mass flow rate, air channel depth, length, and fraction of absorber plate area covered by solar cells. The collector was essentially a single pass air heater with the air flow channel between two metallic plates. The upper plate was painted black, and solar cells were pasted directly on the top surface. The adhesive materials mast be of a special kind such that it is thermally conducting but electrically insulating by Bhargava et al. and Prakash [5,6].

The hybrid system is focus on both actual demand and energy savings the PV solar assisted heat-pump and heat pipe system. The result showed that the PV-SAHP/HP system could reach a average energy efficiency of 61.1 to 82.1% and a exergy efficiency of 8.3 to 9.1% by H.D.Fu et al. [7]. Hybrid air collector with PV module glass to glass gives better performance in terms of overall thermal efficiency compared to glass to tedlar PV/T collector. Overall efficiency decreases with increase in length of the duct by A.S.Joshi et al. [8]. Developed PVT and air conditioning system the electricity produced from PV module is connected into grid. The hot water from the system is supplied adsorption chiller machine for producing cold water by P.Jiraphong et al. [9].

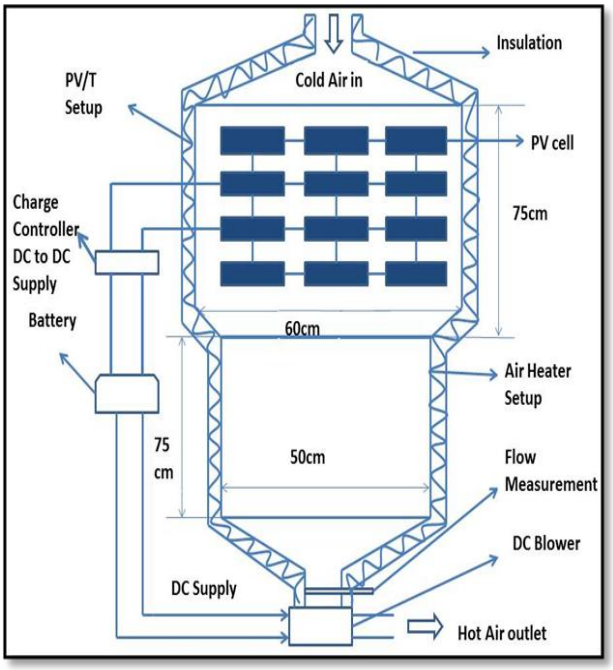
It is researched in thermal, electrical and overall efficiency is 17.8%, 10% and 45% respectively. While inlet air velocity is increasing the overall energy efficiency and thermal efficiency of a PV/T air collector increase by F.Sarhaddi et al. [10]. In this important to use fins as an integral part of the absorber surface in order to achieve meaningful efficiencies for both thermal and electrical output of hybrid PV/T solar collector by Mohd.Yusof Othman et al. [11]. The hybrid PV/T, CPC, and Fins has a potential to significantly increase in power production and reduce the cost of photovoltaic electricity by Mohd.Yusof Hj. Othman et al. [12].

In this work a new design of a Hybrid Solar Air Heater with fins and baffles was studied. The hybrid solar air heating system design Fig.1. The air is enters through the lower channel formed by the aluminum absorber plate and the solar cell is heated directly by the sun. Next it enters the upper formed by the glass by the absorber plate on air heater setup. The fins and baffles on the absorber plate on solar air heater setup to increase the heat transfer to the air and enhances the efficiency of system.

II. EXPERIMENTAL SETUP

A Hybrid solar air heater length and width is 750mm, 600mm on PV/T setup and 750mm, 500mm and 70mm height was fabricated using mild steel plate as shown in "Fig.1". To reduce heat losses to the atmosphere, the collector bottom and lateral sides were insulated with 20mm

thickness of thermocole and to reduce convective losses, the collector top side was covered with a 5mm glass plate.



"Fig. 1" Line Diagram of Hybrid Solar Air Heater

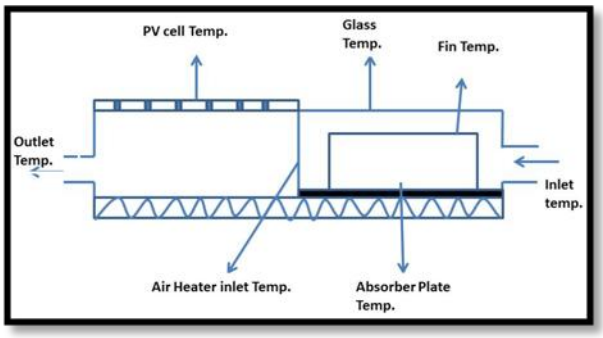
To maintain a uniform distributed flow inside the collector, a conical inlet and exit sections were provided. Using a blower the air was sucked through the lower channel in the PV/T and air heater setup.

TABLE I.

Physical Parameters of Hybrid Solar Air Heating Systems.

S. No	Design Materials and Parameters	Specification
	Air Heater Setup	
1	Tilt Angle	9^0 11 (South Facing)
2	Glass Area	0.375m^2
3	Collector Glazing	Window glass with 5mm thickness
4	Absorber plate	750mm and 500mm
5	Bottom and Side Insulation	20mm thickness of thermo-coal
6	Fins	3-fins 500*40*2mm
7	Baffles	6 baffles 100*40*2mm
8	Fins and Baffles materials	Aluminum
	PV/T Setup	
1	PV cell material	Polycrystalline
2	Number of cells	36
3	PV cell area	0.216m^2
3	Absorber Plate	Aluminum 750*600*2mm
4	Battery	12volt, 18Ah

The hybrid solar air heater was tilted with on angle of 9^0 11 (local latitude angle) with respect to the horizontal position facing south direction to respective the maximum solar radiation. The detailed technical specification of hybrid solar air heater is listed in Table.1.



"Fig. 2" Temperatures Measured in Various Points

"Fig. 3" Photographs on Hybrid Solar Air Heater

2.1 INSTRUMENTATION

Blower is connected to the outlet of the air heater to suck through a gate valve, venturimeter and U-tube manometer. The gate valve is used to control the mass flow rate of air and U-tube manometer is used to find out the mass flow rate by measuring the head difference across the venturimeter. To measure the inlet and exit air temperatures, absorber plate temperature, PV cell temperature, K-type thermocouples were placed at different locations as shown "Fig.2" and connected to the digital temperature indicator. Sun meter is used to measure the solar radiation intensity. The accuracy and errors of measuring instruments as Table.2 The completed fabrication work and photograph on hybrid solar air heater "Fig.3".

TABLE II.

Accuracy and error for various measuring instruments

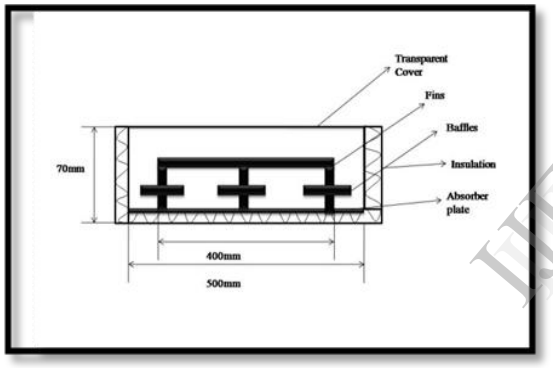
S. No	Instruments	Accuracy	Range	% error
1	Thermometer	± 1^0c	0-100^0c	5
2	Thermocouple	±0.1^0c	0-100^0c	0.5
3	Sun meter	±1 w/m^2	0-1500 w/m^2	2.5
4	U-tube manometer	±1mm	0-1000mm	1
5	Voltmeter	±0.01	0-50volt	0.01
6	Ammeter	±0.01	0-5A	0.01

III. EXPERIMENTAL PROCEDURE

Experiments were conducted with hybrid solar air heater for two configurations show in "Fig.4 and 5"

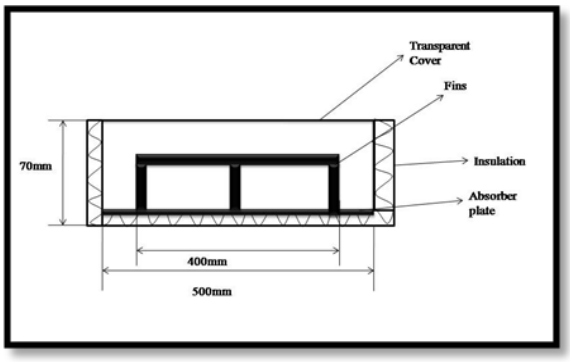
1. With fins and baffles are used

2. Fins and without baffles



"Fig.4" Configuration-1 with fins and baffles

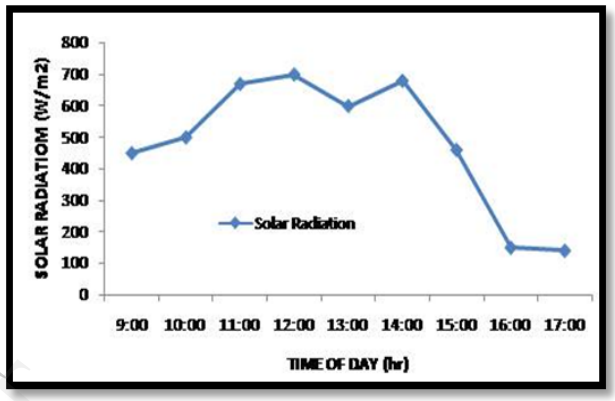
Experiments were conducted on different configuration of hybrid solar air heater from 6 AM till evening 6 PM during March 2014 at Energy park of the National Engineering College, K.R Nagar (9^0 11 N, 77^0 52 E) India. The solar radiation, temperature and manometer readings were observed and recorded for every one hour. For each configuration, the readings were taken for four or five days.



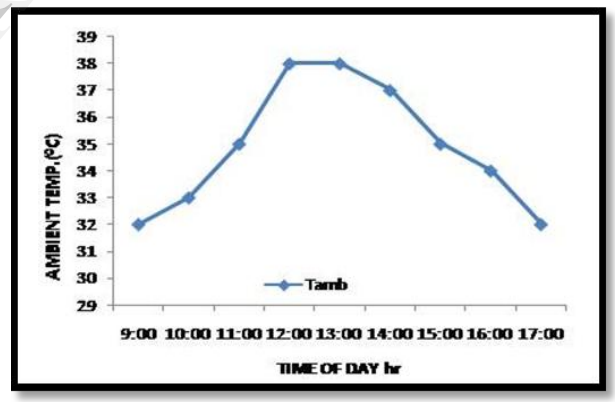
"Fig.5" Configuration-2 with fins and without baffles

IV. RESULT AND DISCUSSION

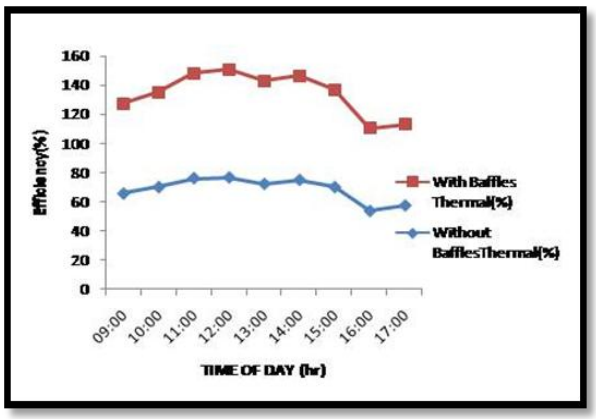
The average solar radiation intensity and atmospheric temperature variations during the experimental period were shown in "Fig.6" and "Fig.7" the maximum solar radiation intensity recorded was 850 W/m^2 at 1.00PM. From the morning till the evening, the ambient temperature was between 30 to 38^0c and the mass flow rate was estimated by using U-tube manometer as 0.01kg/s. The novelty of work is used PV/T setup for both thermal and electrical efficiency are improved. The hybrid systems compared the thermal efficiency of with baffles and without baffles in "Fig.8". The first configuration thermal efficiency will be increased for the fluid is move through all directions.



"Fig.6" Solar Radiation and Time of day

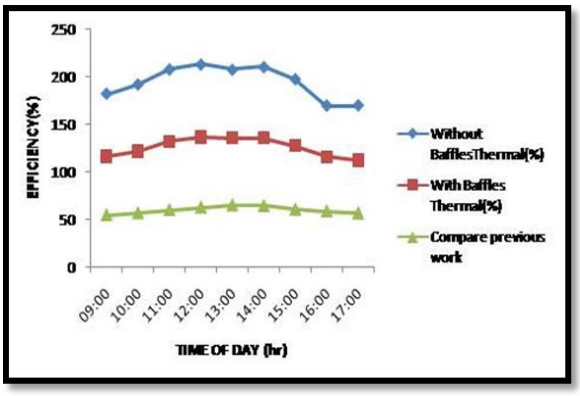


"Fig.7" Ambient Temperature and Time of day



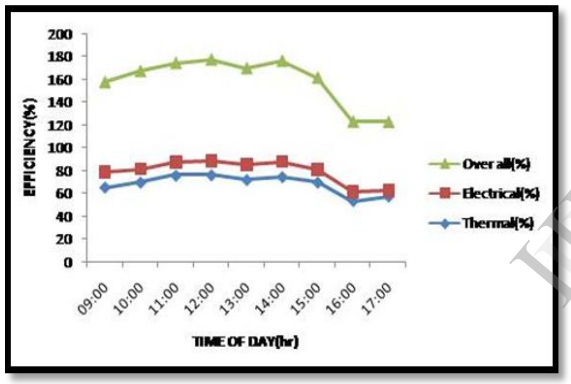
"Fig.8" Compare Thermal efficiency of with and without Baffles

The fins and baffles attached single pass solar air heater efficiency is 55 to 60% for same mass flow rate at 0.01kg/s. K.Mohammadi et.al [21] and in this work the efficiency is increase 70 to 75% and Fig.9. is compare efficiency of various configurations.



"Fig.9" Compared efficency in previous work

In this hybrid system the electrical and thermal efficiency will be increased so the overall efficiecncy is increased in shown "Fig.10".



"Fig.10" Compare Thermal, Electrical, and Overall Efficiency

V. CONCLUSION

A detailed experimental study was conducted to evaluate the performance analysis of hybrid solar air heater with various configurations under the metrological conditions of K.R Nagar (9^0 11N, 77^0 52 E), Tamilnadu, India. This hybrid systems are both thermal and electrical efficiency is increase. The single pass solar air heater fins and baffles efficiency is only 60 to 70%. In this work the efficiency of hybrid solar air heater is exceeds 70% for preheating air is enter from PV/T setup. The hybrid solar air heater is experiment analysis on two configurations, but the first configurations better efficiency then second configuration, for the baffles are used to increase the efficiency of hybrid solar air heater is increased.

REFERENCES

[1] I.N. Kern JR, EC, Russel MC, Combined photovoltaic and thermal hybrid collector system. Proceedings of 13th IEEE Photovoltaic Specialist1978 pp.1153-7.

[2] Florschuetz LW. Extension of the Hottel-Whillier model to the analysis of combined photovoltaic thermal flat collector, Solar Energy,1979 vol. 22, pp.361-6.K. Elissa, "Title of paper if known," unpublished.

[3] Raguraman P.Analytical predictions of liquid and air photovoltaic/thermal flat plate collector performance. J.Solar EnergyEngg.1987, vol. 103 pp. 291-8.

[4] Cox CH, Raguraman P. Design considerations for flat-plate photovoltaic/thermal collectors. Solar Energy,1985, vol.35, pp. 227-45.

[5] AK, Garg HP, Agarwal RK.Study of a hybrid solar system-solar air heater combined with solar cell. Solar Energy, 1991, vol.31pp. 471-9.

[6] Pragash J.Transient analysis of a photovoltaic-thermal solar collector for co-generation of electricity and hot air/water.EnergyConv Manage,1993, vol. 11, pp. 967-72.

[7] H.D.Fu, G.Pei, J.Ji. H.Long . Experimental study of a Photovoltaic Solar-assisted heat-pump/heat-pipe system, Applied Thermal Engineering, 2012, vol. 40, pp.343-350.

[8] A.S.Joshi, A.Tiwari, I.Dincer, B.V.Reddy. Performance evaluation of a hybrid photovoltaic thermal (PV/T) (glass to glass) systems, International Journal of Thermal Sciences,2009,vol.48,pp.154-164.

[9] P.Jiraphong, J.Sirimongkhol, N.Thipjak. A Si Photovoltaic Thermal Solar air-conditioning system in Thailand, IEEE, 2006, pp. 2217-2218.

[10] F.Sarhaddi, S.Farahat,H.Ajam, M.MahadaviAdeli.An improved thermal and electrical model for a solar photovoltaic (PV/T) air collector, Solar Energy, 2010,vol. 87, pp. 2328-2339.

[11] Mohd.Yusof Othman, BaharudinYatim, KamaruzzamanSopian, Mohd. Nazari Abu Bakar.Performance studies on a finned double-pass photovoltaic-thermal (PV/T) solar collector. Desalination, 2007, vol. 209, pp. 43-49.

[12] Mohd.YusofHj.Othman, BaharudinYatim, KamaruzzamanSopian, Mohd.Nazari Abu Bakar. Performance analysis of a double-pass photovoltaic/thermal(PV/T) solar collector with CPC and fins, Renewable Energy, 2005, vol. 30,pp. 2005-2007.

[13] H.G.Teo, P.S.Lee, M.N.A.Hawlader.An active cooling system for photovoltaic modules.Applied Energy, 2012, vol. 90, pp. 309-315.

[14] Y.Tripanagnostopoulos. Aspect and Improvement of hybrid photovoltaic/thermal solar energy systems. Solar Energy, 2007, vol. 81, pp. 1117-1131.

[15] Chen X, Yang H, Lu L, Wang J, Liu W. Experimental studies on a ground coupled heat pump with solar thermal collectors for space heating.

[16] Sharma VK, Colangelo A, Spagna G. Experimental Performance of an indirect type solar fruit and vegetables dryer, Energy Convers Manage, 2010, vol. 51, pp. 2230-8.

[17] Shree kumar A. Techno-economic analysis of a roof- integrated solar air heating system for drying fruit and vegetables, Energy Convers Manage, 2010, vol. 51, pp. 2230-8.

[18] Bari E, Noel JY, Zomini G, Cortella G, Air Cooled condensing systems for home and industrial applications, Applied Thermal Engg. 2005, vol. 25, pp. 1446-58.

[19] Chen Z, Gu M, Peng D, PengC,Wu Z, A numerical study on heat transfer of high efficient solar flat plate collectors with energy storage, Int J Green Energy, 2010, vol. 7, pp. 326-36.

[20] Yeh HM, Theory of battled solar air heaters, Energy, 1992, vol. 17, pp. 697-702.

[21] Mohammadi K,Sabzpooshani M, Comprehensive performance evaluation and parametric studies of a single pass solar air heater with fins and baffles attached over the absorber plate, 2013, vol. 57, pp. 741-750.