Fabrication of a Flat Plate Photovoltaic Thermal Collector

Govind S. Menon
Division of Mechanical Engineering
School of Engineering, Cochin University of Science and Technology, Cochin, Kerala,India

Jacob Elias
Division of Mechanical Engineering
School of Engineering, Cochin University of Science and Technology, Cochin, Kerala,India

Abstract- A PV/T system is a hybrid system with a solar photovoltaic panel anda solar thermal collector that generate electrical and thermal energy simultaneously. The paper describes the fabrication of an Unglazed Flat Plate Collector system and experimentation of a Photo Voltaic/Thermal (PV/T) hybrid system.The photovoltaic/thermal (PVT) concept offers an opportunity to increase the overall efficiency of a PV module through the use of the waste heat generated in the PV module and subsequently cools the PV module.

Keywords – PV/T, Solar, Absorber, PUF

I. INTRODUCTION

The photovoltaic-thermal hybrid solar collector (or PV/T) is an equipment that integrates a photovoltaic (PV) module, for the conversion of solar energy into electrical energy, and a module with high thermal conversion efficiency, which employs a thermal fluid [1]. Most of the incoming solar energy is either reflected or absorbed as heat energy. Consequently, the working temperature of the solar cells increases considerably after prolonged operations and thereafter the cell's efficiency drops significantly. Unglazed collectors increases the electrical efficiency of the solar panel since the glazing is absent and thus reducing convective heat losses [2].Flat plate collectors are easy to manufacture and require low maintenance [3]. Flat plate collectors collect heat from both types of radiation-beam and diffuse.PV/T system is a type of co-generation system that produces power and heat from a single system by absorbing the waste heat from a solar panel [4].

When properly designed, PV/T systems can extract heat from PV modules, heating water or air to reduce the operating temperature of the PV modules and keep the electrical efficiency at a sufficient level [5]. A very recent example in this regard is studied where the performance assessment and comparison of two cascaded solar-assisted process heating systems have been presented,photovoltaic thermal (PVT) cascaded with flat-plate collector (PVT-FPC) and PVT coupled with heat pipe evacuated tube collector [6]. Solar thermal systems and solar PV systems have each advanced markedly, and combining the two technologies provides the opportunity for increased efficiency and expanded utilization of solar energy [7]. The current paper explains the fabrication of a flat plate photovoltaic thermal collector.

II. DESIGN AND FABRICATION OF THE SYSTEM

The fabrication of the system combines two technologies; a solar photo voltaic panel and a solar thermal collector that generate electrical and thermal energy simultaneously. The thermal collector made of rectangular copper pipes is configured as a Parallel-tube Flat-plate collector and is mounted to the reverse of a Poly crystalline PV panel. The collector pipes of rectangular shape helps in increasing the contact area between the pipes and PV panel, thus increasing the heat transfer. Each collector pipe is covered by insulation tape to reduce heat lose (Fig. 1). The PV/T collector, typically consists of a PV module on the back of which an absorber plate (a heat extraction device) is attached. PV modules convert solar radiation into electricity with peak efficiencies in the range of 5–20% [8]. The purpose of the absorber plate is two-fold. Firstly, to cool the PV module and thus to improve its electrical performance and secondly to collect the thermal energy produced, which would have otherwise been lost as heat to the environment. This collected

heat could be used, for low temperature applications such as domestic hot water production for showers and washing. Normally the electrical and the thermal performance of PV/T collectors is lower than that of separate PV panels and conventional thermal alone [9]. The photo voltaic thermal system consist of the combined flat plate collector and solar panel connected *via.* mechanical bonding. The specifications of the entire system is given in Table 1.

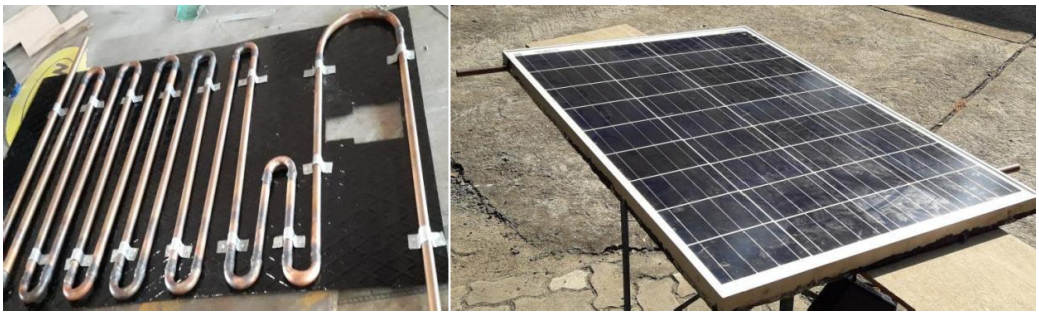


Figure 1. Collector pipes and solar panel

Table - 1 FPC-Flat Plate Collector specifications

Details	**Dimensions**
Length of absorber plate	103 cm
Width of absorber plate	63 cm
Thermal conductivity of plate material	210 W/mK
Absorber plate thickness	2 mm
Insulation material	Glass wool
Heating pipes specifications	0.625 cm dia., 6m length
Length of individual pipes	52.5 cm
Spacing between pipes	4 cm
Thickness of pipes	2 mm
U bend	0.625 cm dia.
Copper pipes loops	7 nos.
Total number of pipes	15
Insulation	PU Foam insulation
Adhesive	Epoxy aluminium paste
Thickness of adhesive	2 mm
Casing material	Aluminium
Dimensions of the casing	107 cm ×67 cm

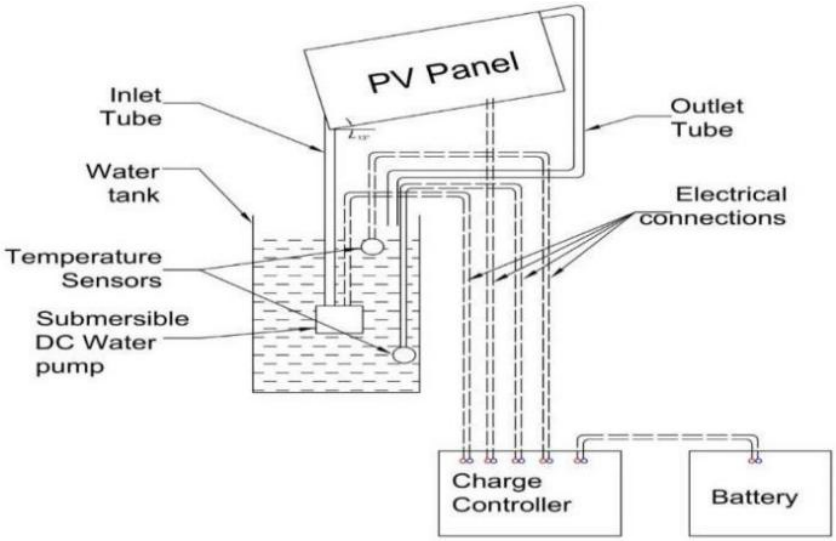
2.1 Fabrication procedure-

The aluminium sheet is cut based on the solar panel surface area and based on the positions where electrical connections are to be given. Both sides of the aluminium sheet are painted with black paint to increase absorptivity. Copper pipes are sized based on the length of the absorber plate and brazed with a U bend. They are then riveted to the aluminium sheet**.** The photo voltaic panel is connected to the absorber plate with the help of integration methods.

2.2 Integration methods-

Thermally conductive adhesives are the most widely used method in integration of PVlayer with the thermal absorber for all kinds of PV/T modules. Thermal characteristics include high thermal conductivity, extreme operating temperature range and good elongation properties, which improves the overall efficiency of the PV/T module greatly. This thermal adhesive integration method is a simple and cost effective one. In the present studies aluminium epoxy paste is used as adhesive. Epoxy adhesive is applied to fix the aluminium

sheet to the reverse side of the solar panel. Adhesive 'M-seal' is applied to the joints to prevent leakage of water. The entire system is closed and sealed with aluminium sheet (made in the form of an external casing). The PUF insulation is poured through the holes drilled in the casing and solid insulation is formed between the pipes.



2.3 PV/T system and accessories-

The systems comprises of storage tanks and temperature sensors, flexible hose (Figure 2). The water is stored in a tank connected to a DC pump in order to circulate the water. The temperature sensors are used to measure the temperature of the PV Panel, outlet hot water temperature and inlet cold water temperature.

Figure 2. Fabricated PV/T system

2.4 Specifications of the system-

Solar Panel - Luminous Polycrystalline, Maximum power = 100 W, Open circuit voltage 22V, Short circuit current 6.06 A, Battery Luminous 110 Ah, Charge controller 6 A, 12 V.

2.5 Material Selection Parameters-

Absorber plate: Aluminium (High thermal conductivity, Light weight), Heating pipes: Copper pipes (Good heat transfer), Pipe bends (U bends), Black paint (To increase solar absorptivity), Insulation - PUF foam (High insulation capacity, good thickness, less air leakage), Casing - Aluminium (Less corrosive property).

III. EXPERIMENT AND RESULT

Photovoltaic technology is one of the finest ways to harness the solar power [10]. Photo voltaic thermal systems are co-generation systems that extract waste heat from the PV system. A PV/T system is a hybrid system with a solar photovoltaic panel and a solar thermal collector that generate electrical and thermal energy simultaneously. A review of literature suggests that most of the earlier research goals were twofold, that is to enhance the efficiency of the solar PV systems and to ensure a longer life at the same time [11]. Initially the PV system is tested for many days and it was found from the experimental values that as the open circuit voltage reduces at noon time and short circuit current increases at noon time since the temperature reduces and consequently the efficiency of the system reduces. In the present studies the fabrication of an unglazed Flat Plate Collector system was done for further experimentation of a Photo Voltaic/Thermal (PV/T) hybrid system. The future applications of photo voltaic technology will utilize the system technology available today and sub-system technology advances can be accommodated through minorsystem changes [12].

REFERENCES

[1] C.A.F. Ramos, A.N. Alcaso, A.J.M. Cardosco, "Photovoltaic-thermal (PVT) technology: Review and case study," I*OP Conference Series: Earth and Environmental Sciences*, *354, pp. 12048, 2014.*

[2] R. Dobriyal, P. Negi, N. Sengar, D.B. Singh, "A brief review on solar flat plate collector by incorporating the effect of nano fluid", *Materials Today: Proceedings, 21, pp 1653-1658, 2020.*

[3] A. Parthiban, K.S. Reddy, B. Pesala, T.K. Mallick, "Effects of operational and environmental parameters on the performance of a solar photovoltaic-thermal collector", *Energy Conversion and Management, 205, 1-13, 2020.*

[4] P. Dupeyrat, C. Menezo, H. Wirth, M. Rommel, "Improvement of PV moduleoptical properties for PV-thermal hybrid collector application," *Solar Energy Materials and Solar Cells, 95, pp 2028–2036, 2011.*

[5] P. Haurant, C. Menezo, P. Dupeyrat, "Full scale experimentation and modelling ofa photovoltaic-thermal (PV-T) hybrid system for domestic hot water applications," *Energy Proceedings 48, pp 581-587, 2014.*

[6] M. Laveet Kumar, M. Hasanuzzaman, N.A. Rahim, "Real-time experimental performance assessment of a photovoltaic thermal system cascaded with flat plate and heat pipe evacuated tube collector," *Journal of Solar Engineering, 144(1), pp 011004, 2022.*

[7] R. Kumar, M.A. Rosen, "A critical review of photovoltaic-thermal solar collectorsfor air heating," *Applied Energy, 2011.*

[8] A.H. Adel, "Comparative study of the performances of four photovoltaic/ thermal solar air collectors," *Energy Conservation and Management, 41(8), pp 861-881, 2000.*

[9] A.K. Bhargava, H.P. Garg, R.K. Agarwal, "Study on a hybrid solar system – Solar air heater combines with solar cells," *Energy Conservation and Management, 31(5), pp 471-479, 1991.*

[10] B. Parida, S. Iniyan S., R. Goic, "A review of solar photovoltaic technologies," *Renewable and Sustainable Energy Reviews, 15(3), 1625-1636, 2011.*

[11] M. Hasanuzzaman, A.B.M.A. Malek, M.M. Islam, A.K. Pandey, N.A. Rahim, "Global advancement of cooling technologies for PV systems: A review," S*olar Energy,137(1), pp 25-45, 2016.*

[12] A.M.K. El-Ghonemy, "Photovoltaic solar energy: Review," *International Journal of Science and Engineering Research, 3(11), pp 1-43, 2012.*