Overall Efficiency Of Photovoltaic Thermal (PV/T) System

Poonam S Pardeshi[1] & Dr. Mrs.Hyacinth J Kennady[2]

[1]Mechanical Department, Marwadi Education Foundation's Group of Institutions, Rajkot,

[2] Mechanical Department, Hindustan University, Chennai

Abstract

As we know that the efficiency of a Photovoltaic (PV) system decreases with the increase in the ambient temperature. Due to this the life of the panel also decreases. Therefore Photovoltaic Thermal (PV/T) System is introduced in this paper. Photovoltaic thermal (PV/T) system consists of PV module along with heat extraction device. PV/T systems can provide simultaneously electricity and heat, achieving also the reduction of PV operating temperatures and keeping electrical efficiency at sufficient level. In this paper the overall efficiency of the PV & PV/T system is compared. It is found that PV/T has higher overall efficiency (ie 31.9 %) when compared to PV system (ie 10.5 %).

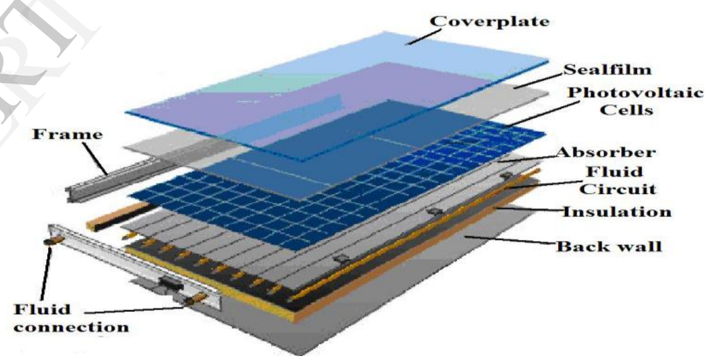
Index Terms: *PV/T system1, Overall efficiency2.*

---***---

1. INTRODUCTION

As we know fossils fuels are depleting day by day. The electricity demand is increasing rapidly with the economic growth of the country. To fulfill the growing demands we cannot rely on the fossil fuel, and hence we need to switch over to renewable sources of energy. We are having abundant solar energy reaching the earth's surface. It is available free of cost. It is non polluting and large amount of energy can be produced. We are aware of photovoltaic system. These systems use solar panels made of silicon and other elements to convert sunlight directly to electricity. There are no moving parts. The systems produce direct current (DC) electricity, the same type of power produced by batteries. Inverters convert the power to alternating current (AC) for powering typical household appliances. Inverters allow the systems to be connected to the electric utility distribution grid, so power can be sold to the utility when not used onsite. These grid-connected photovoltaic are the simplest and most common PV systems installed on houses. PV systems may also be connected to batteries allowing for electric storage. The efficiency of a Photovoltaic (PV) system decreases with the increase in the ambient temperature. Due to this the life of the panel also decreases. PV/T system combine a photovoltaic cell, which converts electromagnetic radiation (photons) into electricity, with a solar thermal collector, which captures the remaining energy and removes waste heat from the PV module. Such systems can be engineered to carry heat away from the PV cells thereby cooling the cells and thus improving their efficiency by lowering resistance. water can be used to extract the heat from the panel.

IJERT



2. METHODOLOGY

Test is conducted in Rajkot on a small panel having area of 0.265 m^2 on 26th September 2013.The ambient temperature for that particular day was noted from 7am to 5pm. Water is passed through the back (rare) side of a panel to remove the heat from the panel. The temperature of the water at inlet was assumed to be equal to the ambient temperature and the outlet water temperature was noted by the thermometer. There was rise in outlet water temperature. The mass flow rate of water was maintained at 0.002 kg/s. The values were put into the equations and the overall efficiency of the panel was calculated.

Table2: shows the parameters of the panel.

Rated Maximum Power	30 W
Rated Voltage	17.25 V
Rated Current	1.75 A
Reference Temperature (Tr)	25˚C
Collector Area (Ac)	0.265 Sq m
Heat removal Factor (Fr)	0.9665
Reference Efficiency (nr)	0.12

The thermal efficiency (η_{th}) of the conventional flat plate solar collector is calculated using the formula below:

$$\eta_{th}=\frac{Qu}{G} \quad 1$$

Where

Qu = actual useful collected heat gain (W/m^2)

G = measurement of incoming solar-irradiation on the collector surface (W/m^2).

Under these conditions, the useful collected heat gain (Qu) is given by:

$$Qu=mC_p(T_o-T_i) \quad 2$$

Where,

m = mass flow rate (Kg/s),

Cp = specific heat of the collector cooling medium (J/kg K),

T_o = fluid outlet temperature (k) and

T_i = fluid inlet temperature (k)

The difference between the absorber solar radiation and thermal heat losses is identified by Hottel- Whillier equations:

$$Qu=A_cF_R[S-U_L(T_i-T_a) , \quad 3$$

S can be identified as

$$S=(\tau\alpha)_{pv}G_T \quad 4$$

Where Ac = function of the collector area (m^2), FR = heat removal efficiency factor, S = absorbed solar energy (W/m^2), UL = overall collector heat loss coefficient (W/m^2 k), T_i = fluid inlet temperature (k), T_a = ambient temperature (k), $\tau\alpha_{pv}$ = product of Transmittance & Absorptance and G_T = solar radiation at NOCT, wind velocity 1 m/s.

Table 2: PV/T collector thermal calculation parameters

Description	Symbol	Value	Units
Ambient temperature	T_a	-	K
Inlet fluid temperature	T_i	-	K
Collector area	A_c	0.265	m^2
Number of glass cover	n	1	-
Fluid flow rate	m	0.002	kg/s
Fluid thermal conductivity	K_{fluid}	0.613	-
Specific heat	C_p	4180	-
Transmittance	τ	0.88	-
Absorptance	α	0.95	-
Heat removal factor	F_R	0.9665	-

Equation to calculate cell temperature is given as:

$$T_{cell}=T_{air}+\frac{(NOCT-20°)}{80}(S) \quad 5$$

3. RESULT

Fig 1 shows the temperature rise in water with respect to time. Water is passed through the back (rare) side of a panel to remove the heat from the panel. The temperature of the water at inlet was assumed to be equal to the ambient temperature and the outlet water temperature was noted by the thermometer. There was rise in outlet water temperature. The mass flow rate of water was maintained at 0.002 kg/s.

IJERT

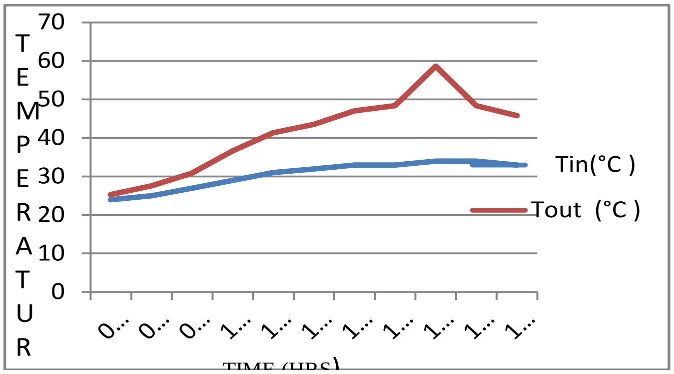


Fig 1: shows the inlet and outlet fluid temperature with respect to time.

Fig 2 shows the rise in cell temperature with respect to ambient temperature. It is observed that at ambient temperature of 33˚C, the maximum cell temperature is around 68˚C. The rise in cell temperature decreases the efficiency of the panel.

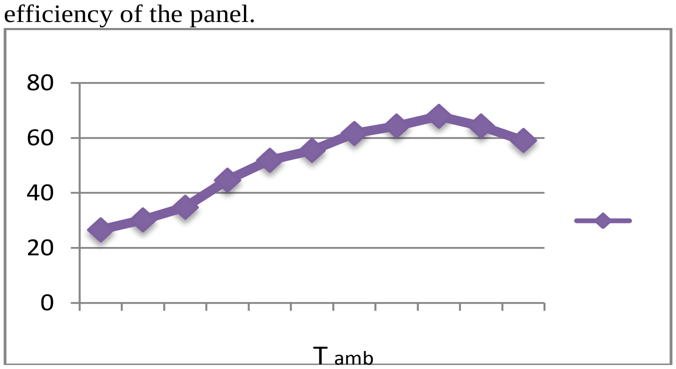


Fig 2: Shows the Cell temperature with respect to time

Fig 3 shows the overall efficiency of PV & PV/T system with respect to increase in ambient temperature. It is seen that the overall efficiency of the PV/T system is higher than PV system by 21.4%.

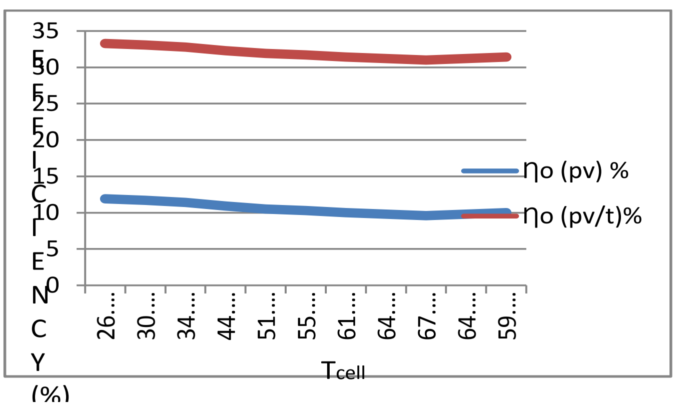


Fig 3: shows the overall thermal efficiency of PV and PV/T system

4. CONCLUSION

It is concluded that the efficiency of PV/T system is higher than PV system. Also the electrical as well as thermal or hot water demands can be met by the PV/T system. The life of the PV panel also increases by removing the heat continuously from the system. It is a efficient way of power generation and also pollution free.

REFERENCE

1. Solar Energy Applications For Agriculture, Chikaire, J. Nnadi, F.N., Nwakwasi, R.N., Anyoha, N.O, Aja O.O., Onoh, P.A. and Nwachukwu C.A.Journal of Agricultural and Veterinary Sciences, Volume 2, September 2010.
2. Sustainable Energy for rural India, National Academy of agricultural sciences, Policy PaperNo.41, New Delhi, September 2008.
3. Consumer energy Information, EREC Reference Briefs, U.S Department of Energy, February 2002.
4. Solar Photovoltaic/Thermal (PVT) Test-bed, Toh Peng Seng, Jiang Fan and Goh Leag Hua, *2012 International Congress on Informatics, Environment, Energy and Applications-IEEA 201, IPCSIT vol.38 (2012) © (2012) IACSIT Press, Singapore.*
5. NYSERDA (2009). Introduction to Solar Energy Applications For Agriculture. New York State Energy Research Development Authority, New York.
6. PV Thermal Systems: PV Panels Supplying Renewable Electricity and Heat Wim G. J. van Helden, Ronald J. Ch. van Zolingen and Herbert A. Zondag, Photovoltaics: Research and Applications, Appl. 2004; 12:415–426.

IJERT