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Mathematical Modeling, simulation and Comparative Study of PVT Collector

Shaikh Sajid[1], Shaikh Sameer[2], Shah Faisal[3], Momin Shahbaz[4],Muqueem Khan[5]
[1,2,3,4,5]*(Deptartment of Electrical Engineering, MMANTC, Mansoora, Malegaon, India)*

***Abstract**:Photovoltaic (PV) technology is technology that converts sunlight directly into electricity.The term Photo knows as light and Voltaic know as electricity. Sun based vitality is winding up most imperative energies later on. The output of Solar cells is varying under temperature of cell changes; iftemperature of PVcell changes its affect the output power from the cells. This undesirable effect of temperature can be partially avoided by applying a cooling system on PV cell with fluid circulation around the PV module. Such system is called photovoltaic/thermal collector (PV/T) or hybrid (PV/T). The main objective of the present work is to design cooling system for the solar cell in order to increase its power output and electrical efficiency of the cell.This hybrid solar system which generates both electricity and heat energy simultaneously. This hybrid PVT Collector consists of PV cells attached to an absorber plate with fins attached at the other side of the absorber plate. By using this system we reduce the temperature of PV Cell.*
***Keywords:**Hybrid Flat Plate PV/T Collector, Solar radiation, Electrical Efficiency, Electrical Power*

I. Introduction

Photovoltaic (PV) technology is technology that converts sunlight directly into electricity. The term Photo knows as light and Voltaic know as electricity. A photovoltaic (PV) cell is also known as Solar Cell, is a semiconductor device that generates electricity when light falls on PV cell. When sunlight strikes a PV cell, the photons of the absorbed sunlight are dislodging the electrons from the atoms of the PV cell. The free electrons then move through the PV cell, creating and filling the holes in the PV cell. Thismovement of electrons and holes that generates electric current in the PV cell. This physical process in which a PV cell or Solar cell converts sunlight into electricity is called as the Photovoltaic Effect.

A single PV cell will produce the power between 1 and 1.5 W at a voltage of 0.5 to 0.6 V under standard test conditions, Where An irradiance of 1KW/m2, standard reference AM1.5 spectrum. 2. A cell temperature of 25 °C. A PV cell converts only a small fraction (approximately less than 20 %) of the irradiance into electrical energy and other about 80% irradiance are converted into heat. As a result, operating temperature of cell will be increase above ambient temperature. If the operating temperature of cell is increased, there will be reduction in the cell voltage. Cell voltage decreases by approximately 2.2 mV per 0C rise in operating temperature of the cell [1].

The equivalent circuit of the PV cell is shown in "Fig.1"

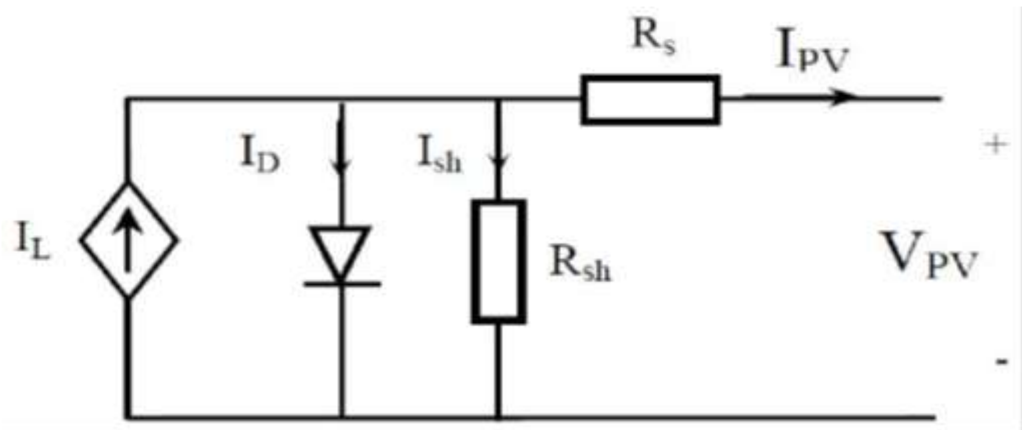

Fig. 1: Equivalent circuit of the photo-voltaic cell

The PV power curves vary with solar insolation and module operating temperature.
Equation (1) and (2) are used to obtain the characteristics of PV array.

$$\text{Ipv} = Il - Io\left(e^{\frac{q(Vpv+Ipv\ Rs)}{AKT}} - 1\right) - \frac{Vpv+Ipv\ Rs}{Rsh} \qquad (1)$$

Ipv = Vpv * Ipv (2)

Where: Ipv is the PV module current (A), Il is the light generated current in (A), Io is the diode saturation current, q is the charge of electron in (coulomb), K is the Boltzmann's constant in (j/K), A is the diode factor and T is the module temperature in (K), RS is module series resistance in (ohm), Rsh is module parallel resistance in (ohm), Vpv is the module output voltage in (V), and Ppv is the extracted PV power in (W).[2]

II. Effect Of Temperature On Pv Performance

Solar cells output is vary under temperature changes. The change in operating temperature will affect the power output from the cells. The voltage is highly dependent on the operating temperature of cell and an increase in operating temperature will decrease the output voltage of cell. [1]

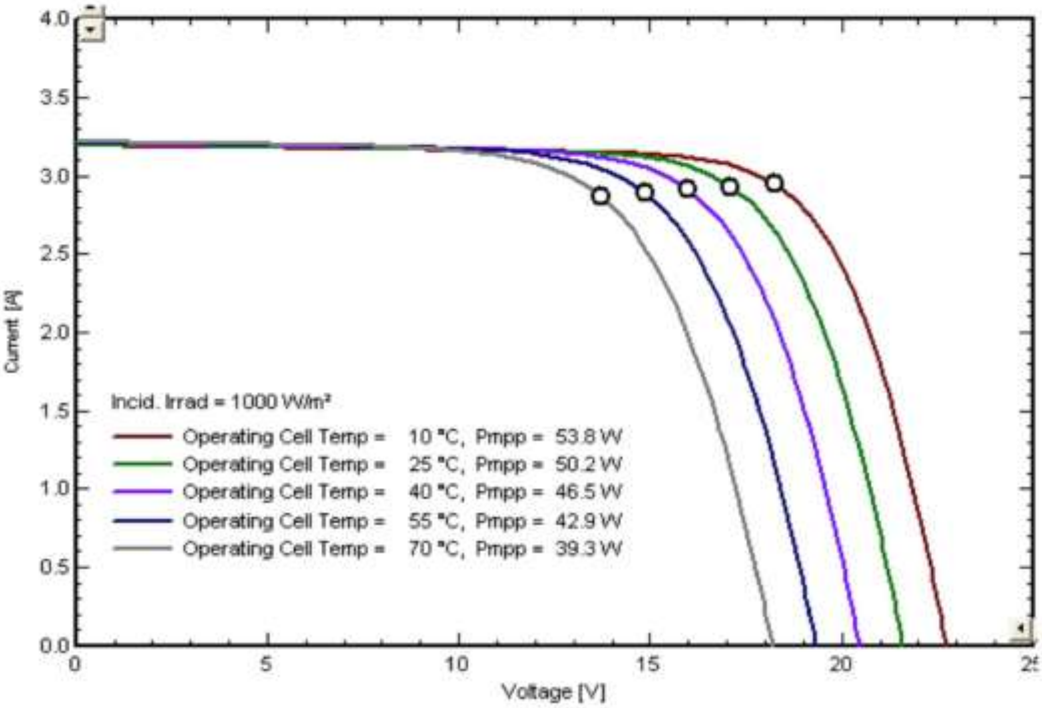

Fig.2: Output I-V characteristics of the photo-voltaic module with different operating temperatures

"Fig.2" shows the effect of operating temperature on I-V characteristic of PV module at constant radiation, from graph it is clear that if we increase the operating temperature of PV Cells, output voltage of cells is decreases.

III. Mathematical Modeling Of Pv Cell

Efficiency of the solar cell power conversion can be given as:

$$\eta c = \frac{Pmax}{Pin} = \frac{\text{Imax}*\text{Vmax}}{\text{I(t)}*\text{Ac}} \qquad (3)$$

Where Imax and Vmax are the current and voltage for most extreme power, relating to sunlight based power (I(t)) and AC is Area of sunlight based cell (Tiwari and Dubey., 2010). The relationships communicating the PV cell temperature (Tc) as an element of climate factors, for example, the surrounding temperature (Ta), sun based radiation (I(t)), and so forth will be talked about in this area. The impact of temperature on the electrical proficiency of a PV cell/module can be gotten by utilizing the central equations. [2]

effect leads to a relation in the form:

$$\eta c = \eta Tref[1 - \beta ref(Tc - Tref) + \gamma \log_{10} I(t)] \quad (4)$$

In which ηTref is the module's electrical proficiency at the reference temperature, Tref, and at sun oriented radiation of 1000W/m2. The temperature coefficient, βref, and the sun based radiation coefficient, Y, are predominantly material properties, having estimations of about 0.0045K and 0.12, separately, for crystalline silicon modules. [2]

The amounts ηTref and βref are regularly given by the PV producer. Notwithstanding, they can be acquired from blaze tests in which the module's electrical yield is estimated at two distinct temperatures for a given sunlight based radiation transition (Hart and Raghuraman., 1982). The genuine estimation of the temperature coefficient, specifically, depends on the PV material as well as on Tref also. It is given by the proportion

$$\beta ref = \frac{1}{To - Tref} \quad (5)$$

In which T0 is the (high) temperature at which the PV module's electrical productivity drops to zero (Garg and Agarwal., 1995). For crystalline silicon sun based cells this temperature is 270 °C (Evans and Florschuetz., 1978). [2]

This data is contained in the Nominal Operating Cell Temperature (NOCT), which is characterized as the cell temperature is estimated under open-circuit when the encompassing temperature is 20◦C, irradiance is 0.8 kW/m2 and wind speed is 1 m/s. TNOCT more often than not values around 45 °C. For varieties in encompassing temperature and irradiance the cell temperature (in oC) can be evaluated precisely with the direct estimation (Luque and Hegedus., 2003) [2]

$$\mathrm{Tc} = Ta + \frac{T\ NOCT - 20}{0.8} * I(t) \quad (6)$$

If weput equation (6) in equation (4) we will obtain important equation (7)

$$\eta c = \eta ref \left[1 - \beta ref * \left[Ta - Tref + (T\ NOCT - 20) * \frac{I(t)}{I(t)NOCT}\right] + \gamma \log_{10} I(t)\right] * 100 \quad (7)$$

ConsiderTref =25°C, average ηref = 12% and average βref = 0.0045K.

IV. Problem Development Its Solution

The efficiency of the solar cell decreases with the increase in temperature of the solar cell panel. Cell voltage decreases by approximately 2.2 mV per 0C rise in operating temperature as discussed earlier. Taking this into consideration, to increase the efficiency of the cell, heat of the cell should be carried away in most efficient ways. The solution to this problem is to add a cooling system to the photovoltaic panel, which will cool the solar cell and the electrical efficiency of the module can be increased. Heat of the Photo Voltaic system can be taken away, by passing air or water over the PV panel. The main objective of this project work is to cool the Photo Voltaic cell panel which will increase the overall efficiency by selecting the proper design configuration and the efficient heat carrying media.

V. System Description

A schematic arrangement alongside related vitality streams and plan parameters for a regular PV/T air warming framework is appeared in “Fig. 3" and “fig. 4” The air enters the upper channel of the photograph voltaic cell is hotter and the stream is facilitated to the lower redirect the other way. As the air goes through the lower channel it is presented to blades (2.5 cm high, 100 cm long and thickness of 1 cm) that are set in the stream heading.

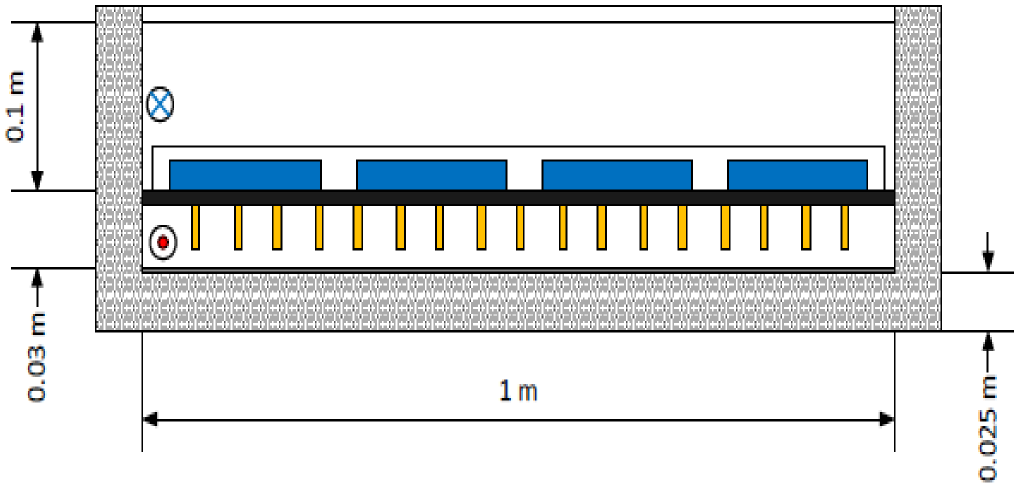

Fig. 3: Schematic front view of a finned double-pass PV/T solar air heater with fins. [3]

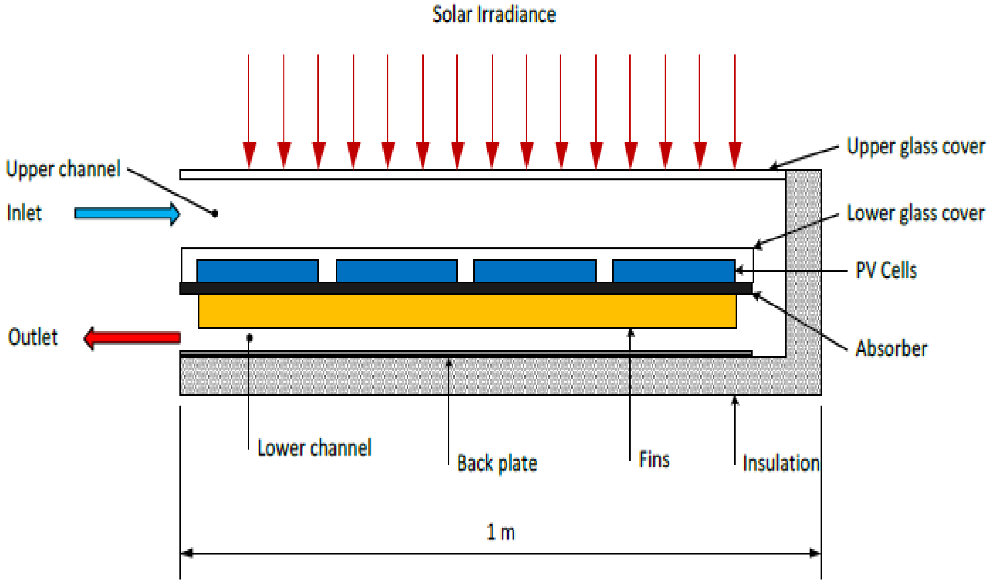

Fig. 4: Schematic cross-sectional view of double-pass PV/T solar air heater with fins[3]

VI. Assumptions

The simulation model based on energy balance on each of the collector components has been developed with following assumptions have been made [3]

1) Steady-state of energy transfer is assumed.
2) The temperature of the flowing air is varying only along the heater length.
3) The temperatures of different system components viz. glass covers, solar cell, absorber plate, and back plate vary along the direction of working fluid flow only.
4) The heat capacity of the transparent covers is very small and, therefore, it is neglected.
5) There is no leakage of air from the system.
6) Side losses from the system are negligible.

The mean absorber surface temperature is assumed equal to the PV cell temperature

VII. Results And Analysis

Relationship between electrical efficiency of solar cell and operating temperature of cell shown in 'fig. 5"

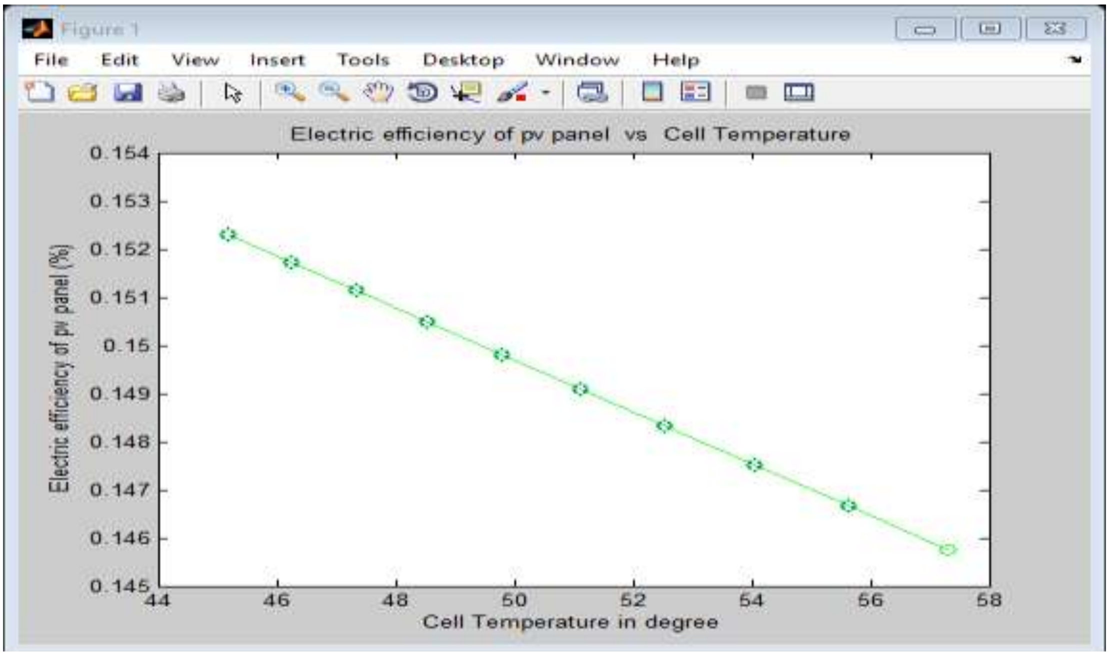

Fig.5: Relationship between the Electrical Efficiency and Cell Temperature

From above graph it is clear that if we decrease the temperature of PV cell then Electrical Efficiency of PV cell is increases. The outcomes from the hypothetical model created are observed to be in better concurrence with those referenced in the reference. The inconsistency between the two qualities is ascribed to the unaccounted misfortunes happening by and by. Additionally, the relative productivity and cell effectiveness temperature coefficient estimations of both the papers are unique. The reference proficiency of12% and cell effectiveness temperature coefficient of 0.0063 is utilized in the reference [2], though in the present work the overall proficiency of 15 % and cell effectiveness temperature coefficient 0.0045 are utilized. stream rate of liquid utilized for cooling the PV cell. It very well may be seen from the chart that there is greatly improved understanding between the anticipated qualities from the hypothetical model created and those referenced in the reference. The electrical efficiency of PV/T Collector increments with the expansion in mass stream rate of liquid.

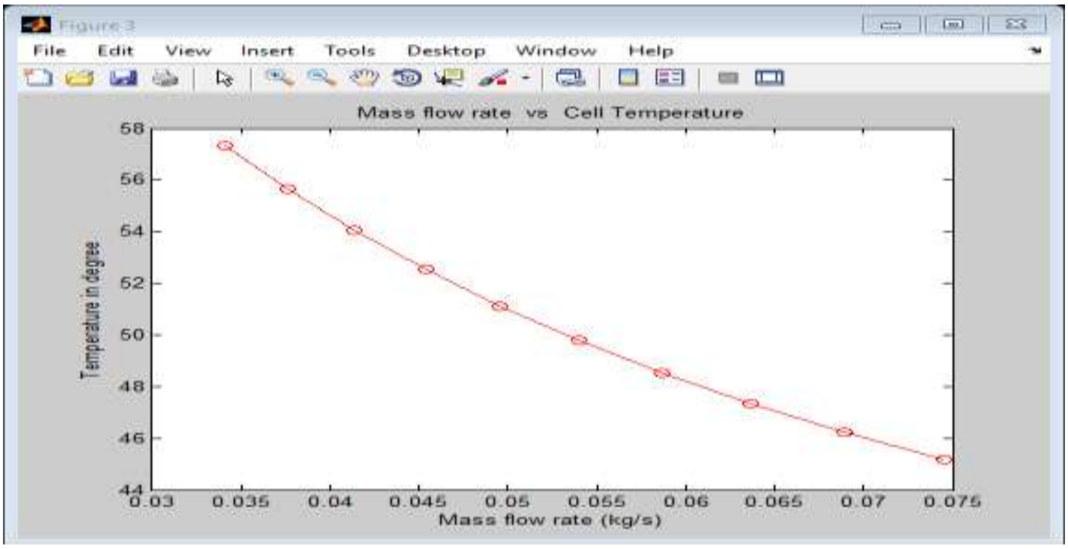

Fig. 6: Relationship between the Mass flow rate of fluid and Cell temperature

From above graph it is clear that if we increase the Mass flow rate of fluid then Cell temperature of PV cell is decrease. Thus Electrical Efficiency of PV cell is increases.

VIII. Conclusion

Sun based cells create greater power when get progressively sun based radiation yet the effectiveness drops when temperature of sunlight based cells increments. Hybrid photovoltaic and thermal collector is the answer for this issue. Simulation model for single pass, single duct solar collector with fins is developed and execution bends are dissected. The synchronous utilization of hybrid PV/T and fincan possibly fundamentally increment in power generation and decrease the expense or cost of photovoltaic power. This framework requires a mass stream rate of 0.074501 kg/s, which is the in particular different mass stream rate esteems and Number of blades required are 7.915937. At the point when the gatherer is working at high mass stream rate, the cell temperature is lessens and efficiencies of PV cell is increment.

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