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Effect of Cooling System on Performance of PV cell for Generation of Electricity

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ABSTRACT

In this review paper, investigation was done by concentrating solar photovoltaic/ thermal system that uses solar radiation in the visible and infrared ranges separately. In this system, photoelectric and photo thermal conversions are achieved independently via the thermal unit and the photovoltaic (PV) module, respectively. The operation of the thermal unit is not affected by temperature limitations imposed by the PV module. The results indicate that water as the working fluid in the thermal unit directly absorbs 33% of the solar radiation. When the mass flow rate was reduced, the water temperature at the thermal unit outlet increased; however, both the temperature and the electrical efficiency of the solar cell remained constant. With the increase in surface temperature of solar cells or panels their efficiency decreases quite dramatically. To overcome the heating of solar cell surface, water immersion cooling technique can be used i.e. it can be submerged in water so as to maintain its surface temperature and provide better efficiency at extreme temperatures. To optimize the efficiency of a solar panel by submerged it in distillated water at different depths. Experiment is done for polycrystalline silicon panel. An evident increase of efficiency is found with increasing the water depth.

Keywords: Solar Cell/panel, Water impression cooling, concentrated PV, Polycrystalline silicon

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I. Introduction

Photovoltaic solar energy (PV) is one of the renewable sources of energy. As it is known, the photovoltaic solar cell is a semiconductor device that generates electricity when light falls on it. A photovoltaic cell converts only a small fraction (~less than 20 %) of the irradiance into electrical energy . The balance is converted into heating of the cell. One of the important parameters that affect the energy output of the PV module or system is the operating temperature. A typical value for PV efficiency loss with temperature is 0.5% / ^{o}C though this varies with the type of cell.[2]Conventional solar cells convert only 3–25% of the incident solar visible light radiation into electricity; the remainder is converted into heat, which increases the temperature of the solar cells and thus reduces the efficiency of electrical output. The temperature of the PV module must always be greater than that of the thermal unit. There are two types of PV/T systems: water and air, depending on the working fluid used. Air-type PV/T systems are simpler and cost less than water -type PV/T systems. Because the water type PV/T systems require a heat exchanger element, their applicability is more limited than that of air-type PV/T systems in terms of both system design and operation. However, water-type PV/T systems can achieve greater efficiencies because of their better cooling performance. [1]There are various factors that affect the efficiency of a solar cell. Cell temperature and energy conversion efficiency are some of them. The reason for the low efficiency of solar cells is their low energy conversion efficiency. A solar cell converts a part of incident solar light into electrical energy the rest being wasted as heat. The infrared light portion of the solar spectrum attributes to this heat loss thus increasing the cell temperature. Cell temperature also has a remarkable effect on its efficiency. Besides the patents and papers reviewed in, recently more and more patents in this area have been filed. As the operating temperature increases the electrical cell efficiency decreases. Earlier the solar cells had an efficiency of less than 1%.From improving the cell material to finding out the optimum operating conditions, the researchers have left no stone unturned in developing technologies to enhance the solar cell efficiency. The maximum efficiency of research photovoltaics is over 40%..Cooling also provides a good solution for the low efficiency problem.[3]

II. LITERATURE SURVEY

Structure of the System

Figure 1 presents the schematic of the structure of our CPV/T system [4]. The system consists of a compound parabolic concentrator and thermal unit placed above a PV module, with an intervening air gap. In the PV module, a Crystalline silicon solar cell (commercially available model) is used to generate electricity, providing power across most of the visible light range (350–800 nm).technology. The top and bottom glass slabs in the thermal unit are composed of silicon dioxide. As the working fluid, water directly absorbs the solar infrared radiation because of its infrared absorption band; moreover, it exhibits high transmittance for most visible light. First, the working fluid flows under the PV cell, cooling the cell to minimize its temperature and attain good electrical efficiency.

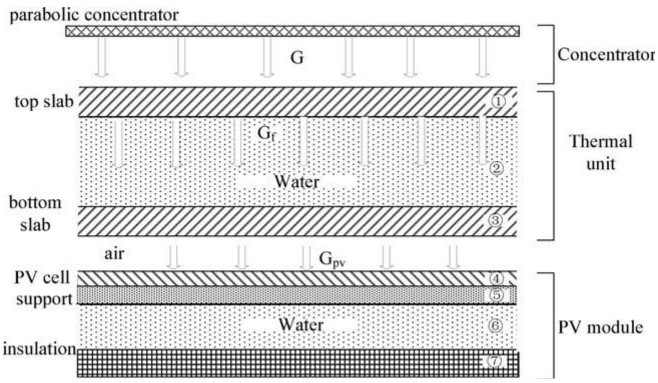

Figure 1. Structure of the concentrating photovoltaic/thermal system investigated in the present study.

In this manner, solar radiation is utilized by the system to attain photothermal and photoelectric conversions separately. This is possible because the working fluid absorbs the solar infrared radiation and the solar cells transmit visible light. Thus, the system can generate three forms of energy simultaneously: electricity (photoelectric conversion), high-grade heat (photothermal conversion), and some low-grade heat (cooling the PV cell) Reducing reflection which also provided cooling replacing the front glass surface with a thin (1mm) film of water running over the face of the panel. It was found that reflective losses in glass can lead to losses in yield of 8-15%. The water decreased cell temperatures up to 22 o C. The improved optics and cell temperatures increased electrical yield 10.3% over the day. the electrical efficiency can be in the range 10-16%. With a sink temperature of 30 o C, the authors estimate a theoretical total efficiency greater than 30%.the cooling method needs to ensure that the operating temperature does not exceed the point at which irreversible degradation occurs in the cell. Zhu et al (2011), use0d water cooling system in a high concentration PV system to avoid the cell degradation. Gardas and Tendolkar (2012) used seven gasses for cooling in PV/thermal system; they found that hydrogen to be the best gas to maximize the output power of the system. Toe et al (2012) studied air cooling system to increase the PV efficiency from (7-8%) to (12-14%).distillated water immersion technique was used to improve the performance and the electrical efficiency of polycrystalline silicon panel. The I-V characteristics of a PV module under different depths of water have been tested.[2]

III. METHODOLOGY

A commercial polycrystalline solar cell with area of 15 cm2 was tested. Characteristics were determined with the use of the electrical circuit presented in figure 2. The experimental set up consisted of the following elements: Rheostat (R) in the range from 0 to 1000 Ω, Ammeter (A), type DT9205A, Voltmeter (V), type MS8205F.

The measurements were carried out in Dohuk, Iraq, at the latitude of 36° 51' during October and November 2012. Measurements were carried out for direct normal irradiance (DNI) using solar radiation intensity meter (Voltcraft). The average value I = 700 W/m2. The air temperature was 36 ^{o}C, and the water temperature range was between 28 ^{o}C and 30^{o}C. wind speed = 1 m/s. Efficiency of the tested solar cell was calculated by applying the following relation:

$\eta = (Vm \cdot Im / I \cdot S) \cdot 100\%$ …….(1)

Where:

Vm – maximum voltage [V],

Im – maximum current [A],

I – intensity of radiation [W/m2],

S – area of the cell [m2].

Fill factor of current – voltage characteristic of solar cells can be calculated by using the following relation:

$FF = Vm \cdot Im / Voc \cdot Isc$ …….(2)

Where:

Voc– open circuit voltage [V],

Isc – short circuit current [A].

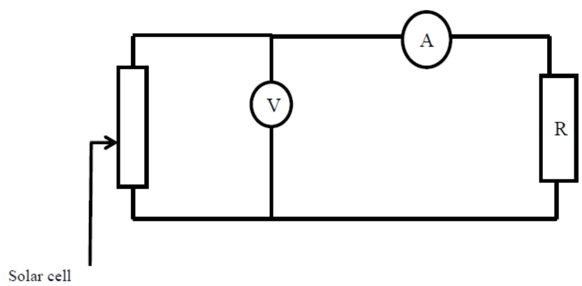

FIGURE2: THE EXPERIMENTAL SET UP

TABLE I: Coefficient values adopted in the CPV/T system.

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I. Figure and Table

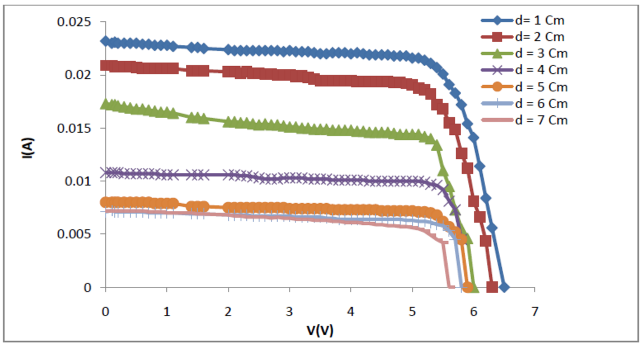

Figure 3: I -V characteristics of studied polycrystalline photovoltaic cell submerged under different water Depths (d).

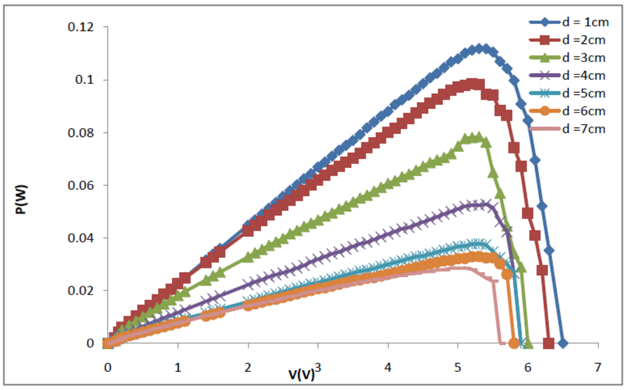

Figure 4: P -V characteristics of studied polycrystalline photovoltaic cell submerged under different water Depths (d).

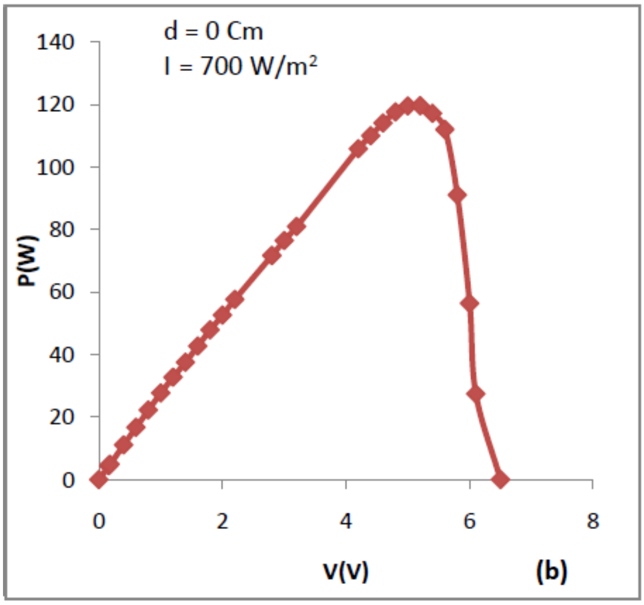

Figure 5: (a) I -V characteristics polycrystalline PV cell

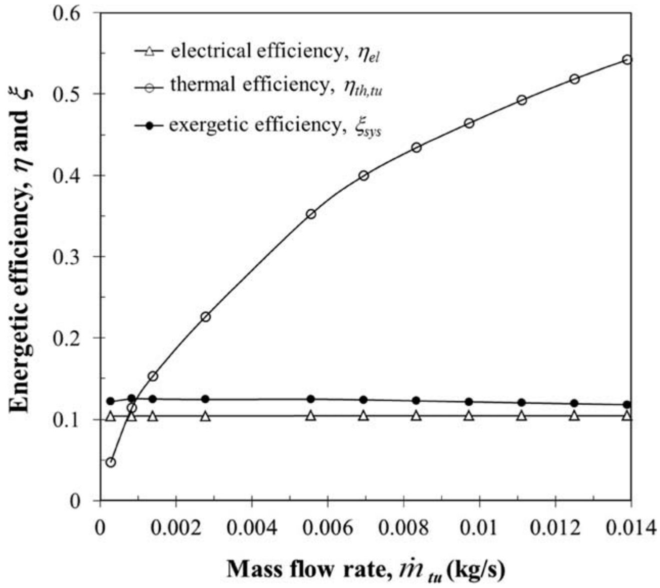

Figure 6: Efficiencies and energetic efficiencies of the system as a function of the mass flow rate, with a fixed incident solar irradiance (G5800 W/m2).

Result Table

Depth (cm)	Average Surface Temperature (^{0}C)	Average Water Temperature (^{0}C)	Average Output Voltage (Volts)	Average Current (Amps)	Average Power Output (Watts)	Fill Factor	Average Electrical Efficiency (%)
0	59.4	-	8.011	0.260	1.346	0.646	4.04
1	34.8	31.5	8.75	0.234	1.418	0.692	4.76
2	32.4	31.2	8.79	0.217	1.321	0.692	4.44
3	33	31.2	8.8	0.210	1.282	0.694	4.311
4	31.2	30.9	8.811	0.205	1.252	0.693	4.211
5	31.8	30.3	8.8	0.203	1.237	0.692	4.16
6	30.8	30.1	8.78	0.198	1.2	0.690	4.03

IV. Conclusion

It was observed that,

(1) When depth of panel submerged in water is 1cm, current was maximum when voltage was up to 5.5v then after it decreases. i.e. with increasing depth the value of current decreases.

(2) With decreases depth of panel submerged in water, power increased 5.5V but after that it was decreases

(3) No considerable effect of mass flow rate on Thermal efficiency.

(4)When depth of water is Zero, then average electrical efficiency of solar panel was 4.04% and depth of water is 1 cm then average electrical efficiency of solar panel was 4.7%

V. Refrences

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