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Effect of Passive Cooling on the Electrical Performance of PV Panel

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Abstract. The qualification of cells declines by raising the temperature, that a reduction in electrical output can be observed. To protect module from this influence, cooling ways are needed to be implemented. So, this paper illustrates a test on the cell quality utilizing passive cooling. A study on PV modules performance including heat sink is achieved to demonstrate the influence of warmth on the power production established by the module. It shows that, passive technique declines the hotness of the PV module considerably and the electrical production is enhanced in case of normal convection. Consequently, the qualification of the PV module having heat sink is achieved 0.9~ 3.8% higher than the PV module in the outdoor.

Keywords: Photovoltaic module

1. INTRODUCTION

As of now, the world confronting the issue of vitality shortfall, a dangerous atmospheric deviation, and crumbling of condition and vitality sources[1]. Fossil fuel reserve has been proven to be much bounded [2].For instance, hydropower plants rely on annual rainfall and wind power rely on weather changes [1].Solar energy which is obtainable on a large scale and clean delivers sufficient energy to meet the needs of the worlds yearly.

The sun`s energy that breakthrough the world is about 1.8×10^{11}MW which is superior to the current consumption average of totally trade power resources on the earth [1].

Solar energy can be extracted from the sun by collecting the energy that the sun awards as radiation. For collecting solar power, many options are available. Thermal energy and Photovoltaic (PV) are the two sources of solar energy[3].generally, thermal systems depend on the energy produced from the radiation to warm up a fluid. Photovoltaic, on the other hand, use the light given off by the sun to convert it into electricity [4]. Each technique has its own features and disadvantages. However, there are some features of PV panels such as ease of installation, clean operation and quiet and the scalability of the energy system. These features make the PV panels the most attractive choice for residential applications [5].

The light concentration and the hotness are essential issues that impact the power transformation in a PV. So, it is required to possess the PV module hotness as small as conceivable for enhancing the module quality [6].

Numerous studies of active PV cooling have been executed in order to enhance the PV power achievement such as air [7], water [8] and refrigerant [9-11] to dissipate- heat from the PV panel. But to drive the cooling fluid, those systems consumed additional energy, and the improvement of electricity performance through the active technique was minor likened with the additional energy ingestion for pump [2].

Experimental Setup

Methodology

The experimental work was carried out on the rooftop of El-Khalafawy building located at Shoubra Faculty of Enginering, BenhaUniversty in CairoEgypt with the latitude of 30.07 and longitude 31.2. The tilt angle for the solar module was inclined at the 30° facing south. The measurement was taken in summer August 2018, from 9:00 AM till 4:00 PM and the data was collected daily at an interval of every one hour.

Experimental Procedures

For examining the passive cooling influence on the performance of a polycrystalline photovoltaic module, two 70W polycrystalline photovoltaic modules having an area of 0.48m^2 were used in this research. The measuring tools that were used in this experimental work include a digital solar power meter which placed at the same level as the PV modules. In addition, the wind speed was obtained by using a digital environmental meter. On the other hand, six thermocouples were fitted on each module at different locations to measure the temperature. Three of those thermocouples were installed at the front face of each of the two modules and the other three thermocouples were installed at the backside.

Furthermore, an aluminum sheet metal plate was designed and fixed at the rear of the module, which have a 2 mm thickness and 205 W/m. k thermal conductivity. Direct cylindrical fins of 20mm diameter were installed at the back of the aluminum sheet metal by means of screws for absorbing warmth. module`s specification are given in Table 1, and the experimental setup of the PV module is shown in figures 1 and 2.

Table 1: Specification of solar panel module

Parameters	Value
Dimensions	800*600*42 mm
Module Type	Polycrystalline
Number of cells	36 Polycrystalline Cells
Maximum power	70 W
Open Circuit Voltage (VOC)	20 V
Maximum Power Voltage	17 V
Maximum Power Current (IMP)	4.1A
Short Circuit Current (ISC)	4.3 A

Fig 1: Front face of a PV modules with thermocouples.

Fig 2: Back face of a PV modules with thermocouples.

Method of Calculations

The results of this experimental work were studied and analyzed in order to get the electrical efficiency of the solar module as follow:

$$P_{in} = I_{(T)}\left(\frac{W}{m^2}\right) \times A_m(m^2) \quad (W) \qquad (1)$$

$$P_{out} = \mathrm{Volt}(V) \times \mathrm{Current}(I) \quad (W) \qquad (2)$$

$$P_{max} = I_{max} \times V_{max}(W) \qquad (3)$$

$$\eta_{el} = \frac{P_{max}}{P_{in}} \qquad (4)$$

Results and Discussions

Effect of temperature on a PV module

The electrical power output of a PV module varies by varying it`s hotness. The influence of passive cooling on the PV hotness is shown in figure 3.

Which shows the great effect of using passive technique on the PV module temperature. Figure 3 illustrates the average value of the PV modules temperature through the three days at maximum solar radiation at 1,00pm. It can be noticed that, the PV modules temperature with and without fins are 51.6ºC and 57.4ºC respectively with a temperature difference between two cases is 5.8ºC. The lessening in hotness caused a visible enhancement in the energy production.

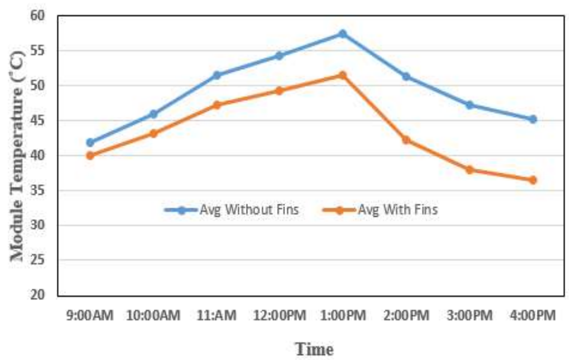

Fig 3: The average value of the three days of PV modules temperature.

Variation of power output during the day time

In this part, module power output is discussed to show whether the cooling mechanism could improve the electrical performance of a system or not. Figure 4 shows the average of the three days for the maximum output power. It can be noticed that the maximum output energy established by the module in the outdoor was 37.67 W at extreme solar radiation at 1:00 pm whereas, the maximum output power developed by the module with fins was 41.32 W. it can be concluded that, there is an increase of 3.65 W in the average power output for the module having fins.

Fig 4: Average Generated Electricity for PV with and without fins systems during the daytime in August 2018.

Variation of electrical efficiency during the day time

The above results will reflect on the electrical efficiency, following figure 5 which represents the average electric efficiencies of with and without fins during the day time in August 2018. It can be observed from the graph that, the PV module that subjected to passive cooling technique has higher efficiency than the PV module that automatically cooled from the outdoor.

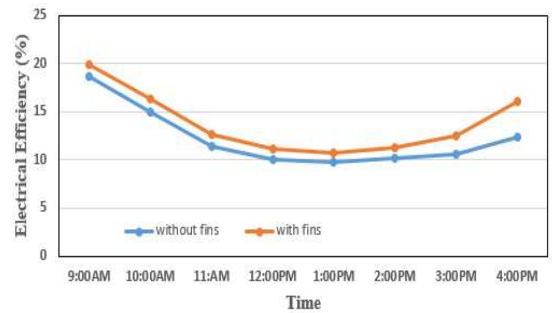

Fig 5: the average electrical efficiencies of the PV modules with and without fins during the day time in August 2018.

Figure 6shows the average throughout the three test days for the PV module with and without fins during the daytime. It is revealed that the current design for PV cooling technique bounces notable improvement in the efficiency likened with the PV without using cooling technique.

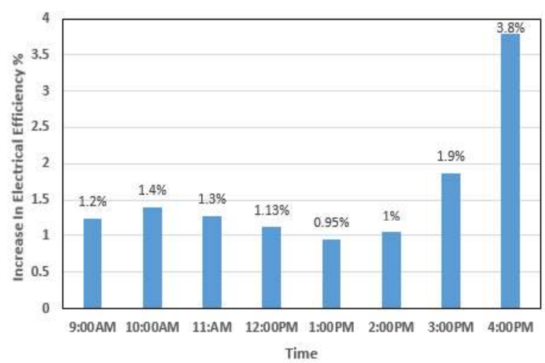

Fig 6: Average value for the percent increase in PV electrical efficiency using cooling technique with PV electrical efficiency without cooling technique in August 2018.

Conclusions

In this paper, an experimental study aims to analyze the passive cooling influence on the of PV cells presentation is obtainable. This study examines the performance of the polycrystalline photovoltaic module with fins. The main conclusions of the present work are as follow

- For the practice, the maximumhotnessreleasedmeaningfullyby5.8º C and the power output increased by 3.65W.As the power output increases the electrical efficiency of the module increase.
- The techniques of PV modules are vital to recover the electrical qualification by 0.9%

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