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Passive cooling using perforated aluminum plate to improve efficiency on monocrystalline of 100 Wp photovoltaic

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Abstract. Many researchers had applied various cooling techniques to reduce the operating temperature of PV cells so it will not exceed the temperature limit. If the operating temperature is exceeded, it can worsen the performance of the PV panel system. Passive cooling is one of the cooling techniques to reduce the operating temperature and increase the efficiency of the PV panel. Cooling operation without the addition of electrical energy is a new original idea, namely passive cooling which uses perforated aluminum plates mounted behind the PV panels. Research that has been carried out using perforated aluminum plates, hole diameter of 5 mm, hole spacing of 200 mm, and total holes of 1551 can increase efficiency by up to 57.64 percent on 100 WP monocrystalline PV panels.

1. Introduction

Solar energy is one of the important renewable energy sources which has attracted the attention of many researchers in the world to be developed. There are two types of energy that can be produced from solar energy, namely electricity and heat energy. One way to convert solar energy into electrical energy is to use photovoltaic (PV) panels. The PV panel can directly convert the incident of solar radiation into electricity that is efficient, sustainable, and environmentally friendly [1] [2].

In general, PV panels are only able to convert a small portion of solar radiation into electricity. The remaining part of the solar radiation will be converted to heat, which can increase the temperature and reduce the performance of the PV panel. The maximum expected PV panel temperature in the presence of solar radiation is 1000 W/m², or about 70% of the absorption rate in the absence of wind conditions and the temperature is 60°C, whereas for wind speeds higher than 4 m/s, the PV panel temperature it will be lower than 40°C [3] [4]. Maximum power output, open circuit voltage, and short circuit current are some of the main parameters that are affected by variations in the temperature of the PV panel. In other words, the open circuit voltage and maximum output power decrease with temperature rise while short circuit current increases [5].

The extraordinary effect on photovoltaic performance is presented by cell temperature. They note that the temperature coefficient is negative for the charging factor, the open-circuit voltage, and the maximum output power while positive for the short-circuit current. Photovoltaic output power and ambient temperature are directly proportional. Therefore, the output power produced by photovoltaic is higher for low ambient temperature intervals than high temperature intervals.[6][7] investigate



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experimentally and numerically the impact of cell temperature on photovoltaic panel performance with a constant irradiance value.

The results show that the efficiency and output power decreases with increasing cell temperature, the decrease in efficiency is caused by temperature differences and hence the location of the PV panels is an important factor to consider. Cell temperature has a significant impact on the performance of photovoltaic cells.

Therefore, this research focuses on passive cooling techniques to reduce PV cell heat and improve PV cell efficiency using perforated aluminum plate.

2. Passive cooling techniques for PV panel

Passive cooling techniques can be divided into three main groups: air passive cooling, water passive cooling, and conductive cooling. Conductive cooling mostly ends with passive cooling of air, but an important difference is that the prevailing heat transfer mechanism of PV cells is conductive.[8] worked on experimental studies on polycrystalline PV cells under controlled conditions.

Two PV cells are used: one with aluminum fins as a heat sink, with thermal grease applied and one without a heat sink. Lighting varies from 200 to 800 W/m². A relative increase in electrical efficiency of 9% has been obtained through the use of passive cooling with coolant.[9][10] have shown that the depth of the flow channel under the PV cell has a significant effect on passive cooling, for a larger PV surface (1.95 m²). It has been shown that, for a length-to-depth ratio of 0.085, the PV module heats up 5-6 °C when compared to the PV module in a normal installation. It was noted that the temperature difference increases with increasing insulation. In other words, passive flow channels can have the opposite effect on cooling the PV module.

Water passive cooling is somewhat more efficient, mainly because of the higher thermal capacity of water. Several studies have been made with front and back cooling.[11] used a submerged technique to cool down the mono-crystalline PV module in water. The effect had limited success: the temperature was maintained at 30 °C which in turn yielded a relative efficiency increase of 20 %, but insulation intensity dropped with depth. However, at a depth of 4 cm, relative efficiency is increased by 11 %.

3. Experimental

This research was carried out on two monocrystalline PV panels with a capacity of 100 wp in the energy technology laboratory. The research methodology was to experiment using a perforated aluminum plate mounted under a PV panel, testing carried out with and without cooling.

Data collection for short circuit current (Isc), open circuit voltage (Voc), panel temperature and light intensity, datalogger is done using temperature, current, voltage and intensity sensors. 4 temperature sensors are installed at the top and bottom of the panel, one sensor is installed for room temperature, while the current sensor is installed at the output panel when short circuit as Isc, the voltage sensor is mounted on the output panel in an open circuit as Voc.

The data logger in the program uses the Arduino mega-2560 by using SD-Ram as a data storage facility that is connected to a computer, so that the data obtained is real-time and better than manual data retrieval.

The lighting uses 12 halogen lamps, each with a capacity of 1000 watts installed at the top of the panel within 30 cm show on Figure 1.as .design experimental (indoor)

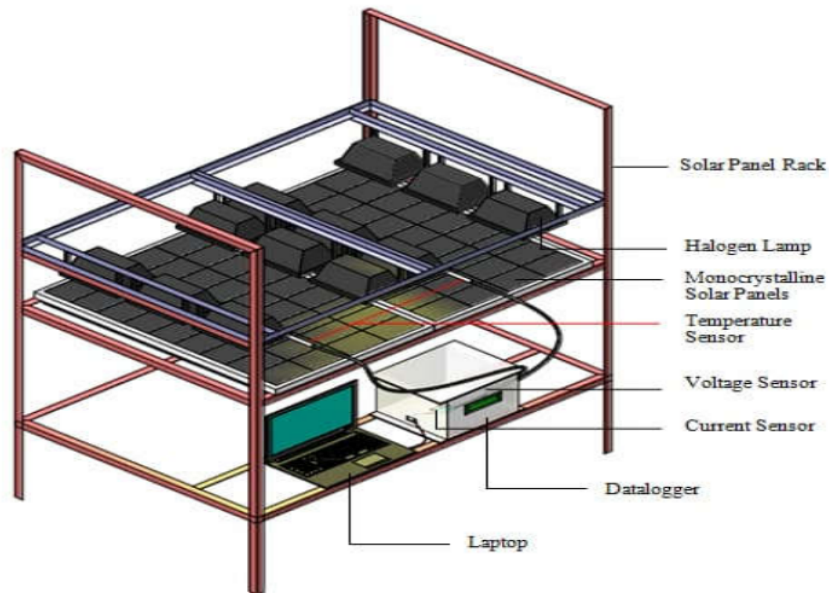


Figure1. Design experimental (indoor)

3.1. PV panel

Two units of monocrystalline photovoltaic panels with a capacity of 100 wp for 2 units, mounted parallel to the panel rack, one of which is installed perforated aluminum plate on the back

The specifications of the PV panels are explained in Table .1.

Table 1. The specifications of the PV panels

Electric Rating	Specification
Cell Type (2 units)	Monocrystalline (1020 x 670 x 30 mm)
Rated Maximum Power (P_{max})	100-Watt Peak
open-circuit voltage (V_{oc})	22.5 V
short-circuit current (I_{sc})	5.91 A
Voltage at P_{max}	18.30 V
Current at P_{max}	5.47 A
nominal operating cell temp (NOCT)	47+ \pm 2°C
Maximum System Voltage	1000 V_{DC}
maximum senes fuse rating	15A
operating temperature	-40°C-+85°C

3.2. Cooling media

Perforated aluminum plates as the cooling media used are respectively described.

Table 2. Dimensions of aluminum perforated plates.

Name of parts	Specification
Dimension	1020 x 670 x 30 mm
Hole diameter	5 mm
Distance between holes	20 mm
Number of holes	1551
Arrangement of holes	In line

4. Experimental results and Discussion

Experimental results show the comparison of PV panel temperatures in Figure 2. Clearly shows a decrease in PV panel temperature using perforated aluminum plate as a cooling medium, when 11.44.06 the upper surface of the PV panel temperature using perforated plate (T 1) shows 49.38^oC while the upper surface temperature PV panel without perforated plate (T 2) of 62^oC as well as in T1.2=34^oC and T2.2=41.19^oC.

The increase in voltage and current is shown in Figure 3. where the highest V.1 is 18.48 V and the highest V.2 is 14.71 V. Current I.1 = 4.26 A, I.2 = 3.41 A.

In figure 4 the highest power P.1 = 78.38 W, P.2 = 49.48W and the highest efficiency η .1 = 7.63%, η 2 = 4.84%.

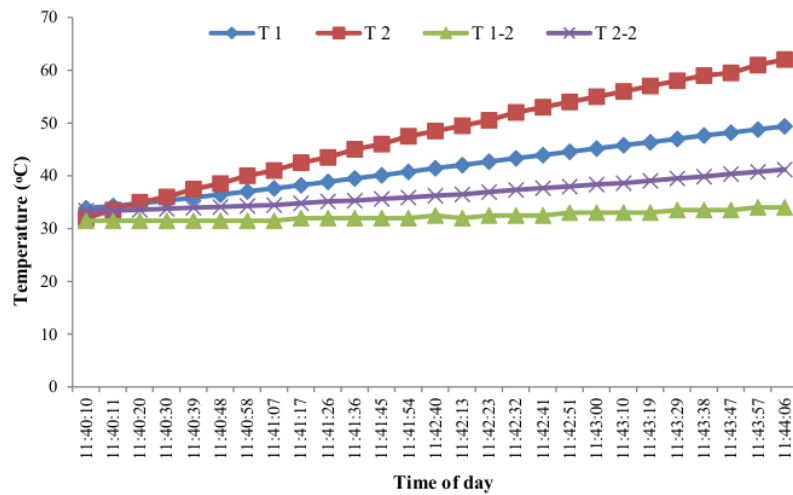


Figure 2. Comparison between upper surface temperature PV panel using perforated aluminum plate (T 1) PV panel without perforated plate (T 2) and below surface temperature PV panel using perforated plate (T 1-2) PV panel without perforated plate (T 2-2).

Figure 2 shows that the percentage decrease in temperature of the perforated plate T 1 compared to without the perforated plate T 2 to 20.35% on the top surface of the PV panel, while the percentage of temperature decrease brought to the surface of the PV panel using a perforated PV plate (T 1-2) without perforated plate (T 2-2), reaching up to 17.45%.

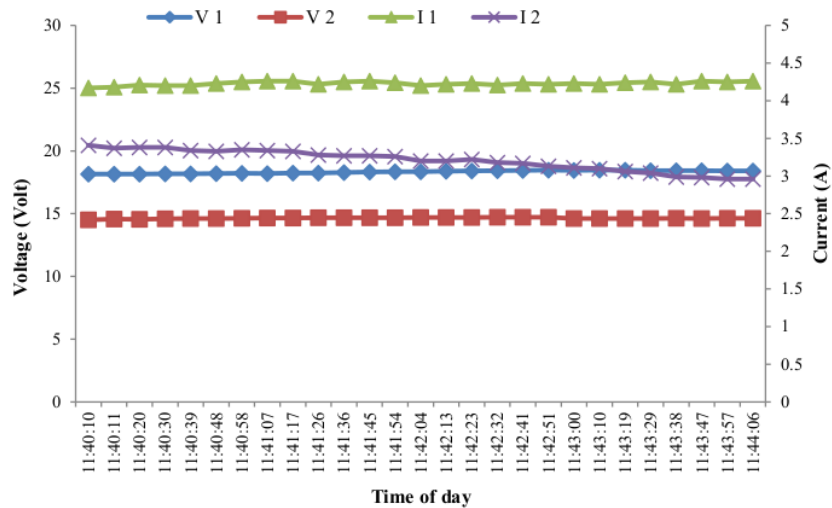


Figure 3. Comparison between voltage of PV panel using perforated plate (V 1) PV panel without perforated plate (V 2) and current of PV panel using perforated plate (I 1) PV panel without perforated plate (I 2)

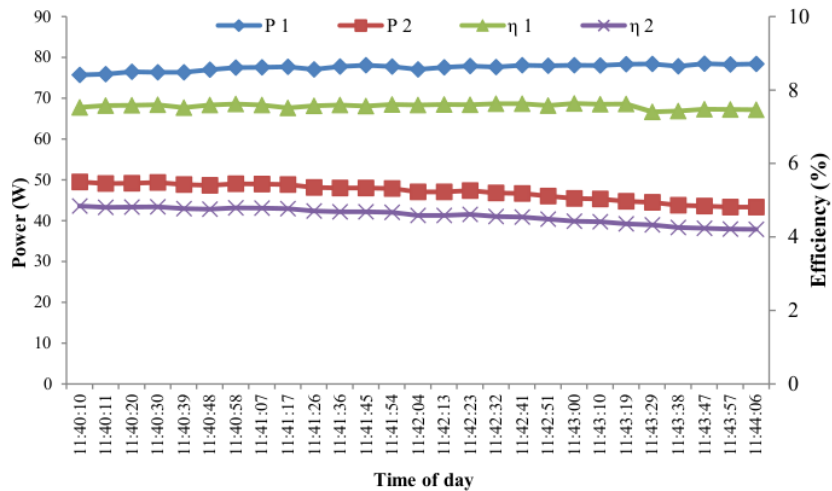


Figure 4. Comparison between power of PV panel using perforated plate (P 1) PV panel without perforated plate (P 2) and efficiency of PV panel using perforated plate (η 1) PV panel without perforated plate (η 2).

5. Conclusion

Passive cooling method using perforated aluminum plate with a hole diameter of 5 mm can increase efficiency by 57.64 % compared to PV panels without cooling.

The addition of perforated aluminum plate to PV panels mounted on the back surface of the PV panels can reduce the temperature of the upper panel by 12.62 °C or 20.35% compared to PV panels without cooling.

The conclusion of this experimental research shows a decrease in temperature on PV panels that use perforated aluminum plates and improve the efficiency of PV panels.

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