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The cooling effect of polycrystalline type PV panels using perforated aluminum plates

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Abstract. A study has been conducted to improve the efficiency of Polycrystalline type PV panels. This research was conducted at the Energy Technology Research Laboratory, Engineering Faculty, Sriwijaya University, South Sumatra, Indonesia. The disadvantage of PV panel, when receiving solar radiation, it will increase the temperature of the PV panel but decrease the efficiency. This study uses a perforated aluminum plate with hole diameter of 2.5 mm. The plate is placed behind the PV panel. The dimensions of the plate are 960 mm x 600 mm x 20 mm and the number of holes of 1457. The specifications of PV panels are 1020 mm x 670 mm x 30 mm, Polycrystalline type PV panels, maximum power of 100 WP. The results showed that the PV panels given a perforated aluminum plate cooling had higher efficiency than those not given perforated plate cooling.

1. Introduction

PV panels have the potential to be developed as energy conversion equipment. These PV panels are able to convert solar energy into electrical energy for countries that have a hot climate all year round. Indonesia is one country that has this potential. South Sumatra Province is one of the regions in Indonesia that has this energy source. Although, this province is a storehouse of energy storage for the country of Indonesia, but the energy reserves taken today are still fossil-based (oil, coal, and gas). This type of energy decreases because it takes a long time to produce this energy again. Therefore, it is time to reduce the use of fossil energy and switch to using this abundant and environmentally friendly source of solar energy. Furthermore, the Indonesian government has made policies to increase the use of new and renewable energy, one of which is the use of solar energy to produce electricity for households, street lights, and traffic signs along the road. In fact, solar energy is one source of energy that can be used as electricity generation and to support transportation and industry.

Based on research results that increasing the temperature of the PV panel will reduce its efficiency [1]. Several ways have been investigated by researchers to improve the efficiency of this PV Panel, such as utilizing Phase Change Material (PCM) technology [2], [3], using water or air as a cooling medium [4], thermoelectric cooling [5], using program [6], etc. Cuce E. et.al., 2011 [7] have used fin cooling to produce better PV panel efficiency compared with without fin cooling. Amelia A. R. et.al., 2016 [8] have done research, the effect of PV panel temperature on its efficiency. The decline in the efficiency of PV panels can be caused by dusk factor on the surface [9]. Even Gholampour M. et.al., 2014 [10] have research on perforated plates and PV panels. The results show that increasing the air mass flow rate using a fan can increase the PV panel cooling. It has been investigated cooling using a fan so that the temperature of the PV panel decreases and can increase the efficiency of the PV panel [11].

The use of PV panels is to produce electricity for household equipment, vehicles, to drive a pump for irrigation needs, etc. Some of these PV panel [12] consists of PV panel research to produce electricity for Air Conditioning equipment for preserve of agricultural products. Furthermore, Abdul Hadi N K et.al., 2018 [13] on thermal storage uses Phase Change Materials (PCM), in which the PV panel serves as a medium for receiving solar radiation and this system is used to produce a freezer. Adejuyigbe S. B. et.al, 2013 [14] utilize PV panels to conduct electricity for office equipment. Bhattacharjee B. et.al., 2019 [15] utilize PV panels to drive water a pump, and water is used for agricultural and household needs.

In this paper, the problem of PV panel efficiency has been reviewed again when PV panels reserve solar radiation and high temperatures as previous researchers have done. Cooling media used in the form of perforated plates made of aluminum without using a fan to suck hot air or cooling with free convection heat transfer. The perforated aluminum plate is placed at the below of the PV panel. The PV panel used is 100 Wp type Polycrystalline. This research is a continuation of the initial research that has been done but the power of PV panel used is still small, namely 8 Wp Polycrystalline type [16].

2. Experimental Procedure

Pollycritalline type PV panel mounted cooling media on the below to reduce the temperature of the panel. The cooling media used is perforated plates. This cooling media is made from aluminum. Figure 1 shows the structure of PV panels and perforated plates.

The PV panel tested consisted of 2 units, namely one unit without cooling media and one unit installed with cooling media in the form of perforated aluminum plates. In addition, some additional equipment was used in this test, such as solar charge control (SCC), batteries, and cables. Measuring instruments used consist of temperature measuring devices using K type thermocouple wire, measuring wind speed using anemometer, and measuring solar radiation intensity using pyranometer equipment, measuring electric current using current meters, and measuring voltage using voltage meters.

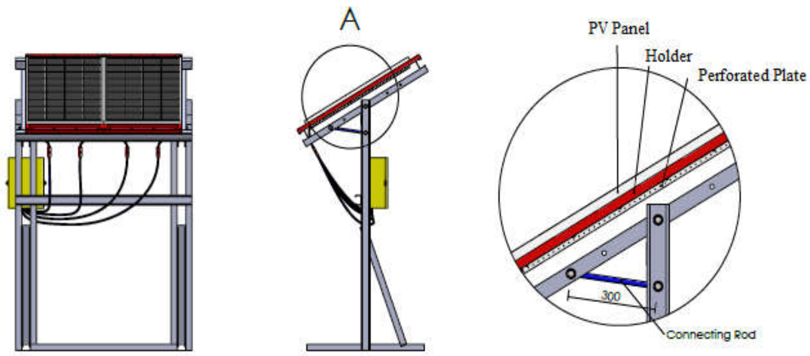

Figure 1. Structure of PV panels and perforated plates being tested

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

Table 1. PV panel specifications and perforated cooling media

	Spesification	Description
PV Panels:	2	units
Dimension (mm)	1020 x 670 x 30	mm
PV panel type	*Polycritalline*	-
Maximum power (P_{max})	100	W_p
Voltage at P_{max} (V_{max})	18	V
Current at P_{max} (I_{mp})	5.56	A
Maximum system voltage (DC)	1000	V
Perforated Aluminum Plate:	1	unit
Dimension	960 x 600 x 20	mm
Hole diameter	2.5	mm
Number of holes	1457	holes

3. Result and Discussion

Solar radiation that comes to a PV panel surface consists of two kinds, namely direct and diffuse solar radiation. When testing this PV panel, the climate in the South Sumatra Province of Indonesia is a hot climate. The following shows the data taken on February 4, 2020 (Figures 2 through 5).

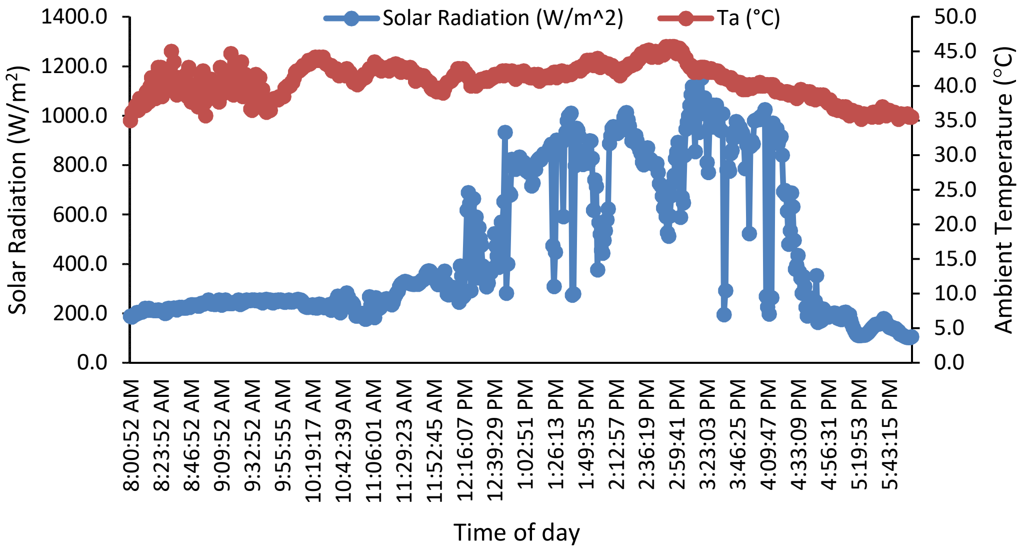

Figure 2. Comparison between ambient temperature and solar radiation on February 4, 2020

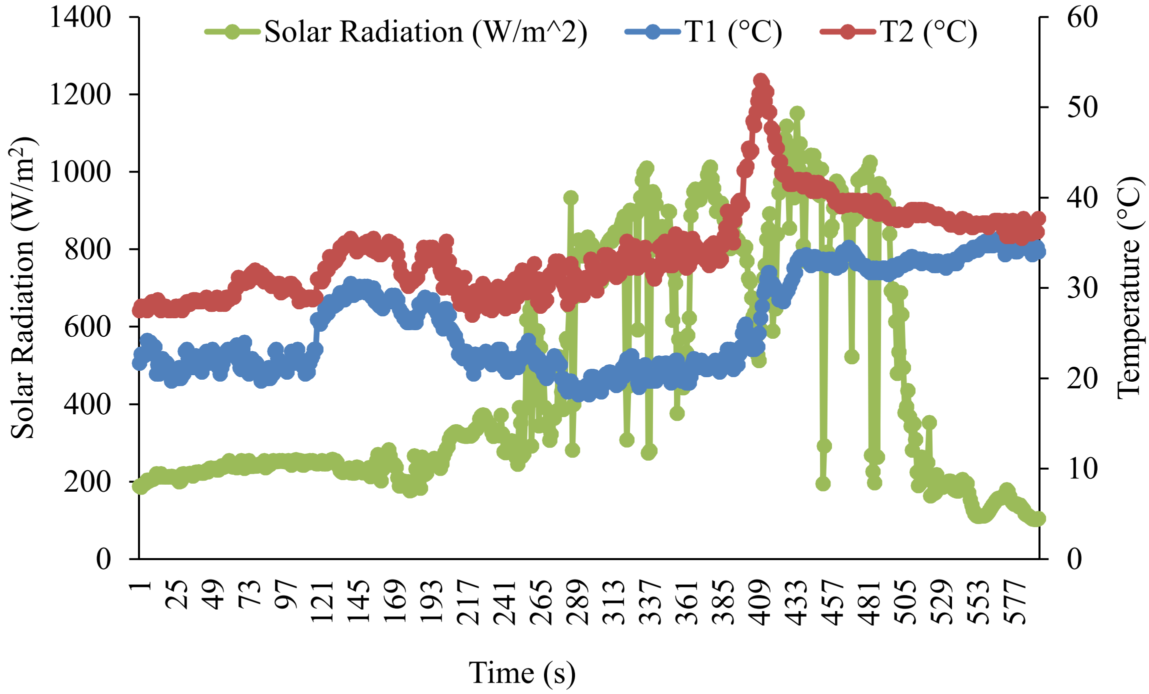

Figure 3. Comparison between PV panel surface temperature using perforated plate cooler (T1), PV panel surface temperature without cooler (T2) and solar radiation on February 4, 2020

As shown by the data taken in the field in Figure 3, the surface temperature of PV panels that do not use perforated aluminum plates (T2) is higher than the surface temperatures of PV panels that are cooled with perforated aluminum plates (T1). Likewise, in Figure 4 the opposite occurs, the tendency of the surface temperature under the PV panel not to use perforated aluminum plate (T2-2) is lower than the surface temperature below the panel which uses perforated aluminum plate cooler (T1-2). This event is interesting to study because the power produced by PV panels that use perforated aluminum plate cooler (P1) has higher compared to PV panels that do not use perforated aluminum plate cooler (P2) as shown in Figure 5.

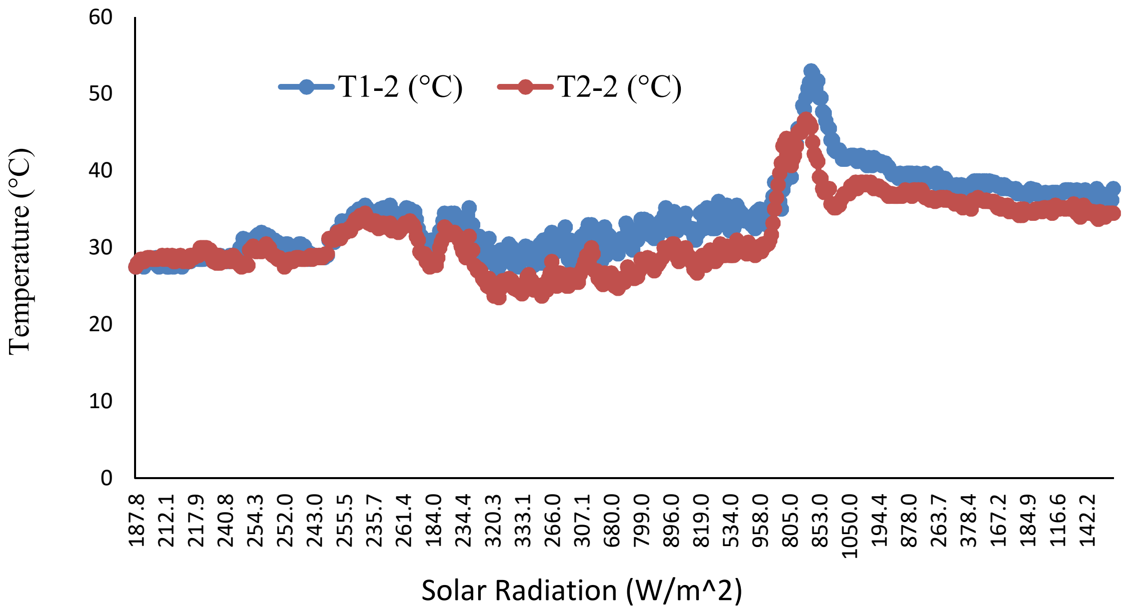

Figure 4. Comparison between the below surface temperature of the PV panel using perforated plate cooler (T1-2) and without perforated plate cooler (T2-2) on 4 February 2020

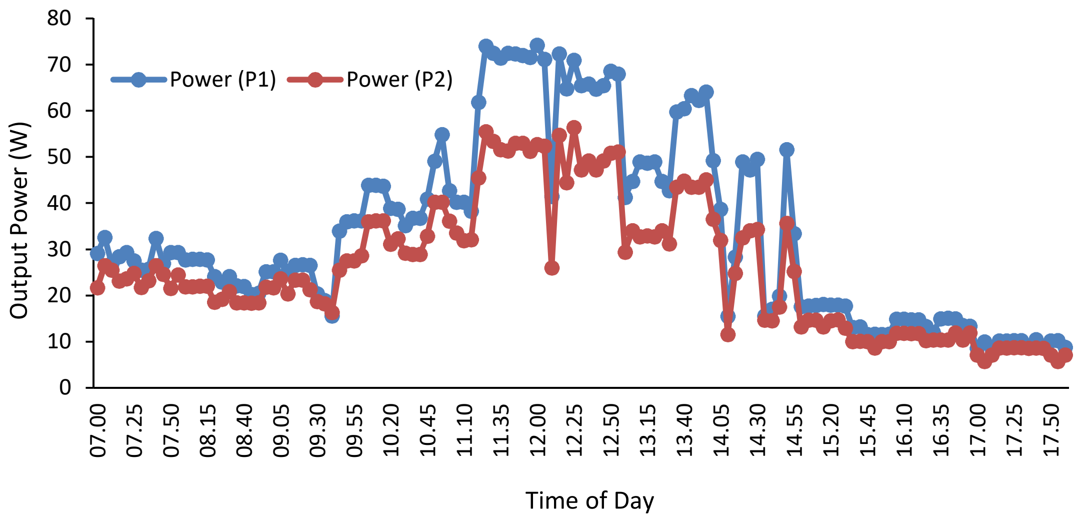

Figure 5. Comparison between PV panel output power using perforated plate cooler (P1) and PV panel output power without cooler (P2) on February 4, 2020

Not all of the solar energy coming to the surface of a PV panel can be used as the output power of a PV panel. Some of this energy will be lost to the atmosphere as lose of heat convection. The first, heat lose is the transfer of heat from the top surface of the PV panel to ambient air. The second, heat lose is the transfer of heat from the back surface of the PV panel to ambient air to holes in the perforated aluminum plate or to ambient air for without perforated aluminum plate.

The intensity of the sun or solar radiation (I_R, W/m^2) that comes to the surface of the PV panel (A_p, m^2) will effect the current (I, Ampere) and voltage (V, Volt) that produce by a PV panel. The efficiency of the PV panel (η) is reduced if the intensity of the sun is high as shown in the equation (1). The results of the efficiency calculation are shown in table 2 for Sunny weather conditions, namely January 21, 2020; February 4, 2020; and February 05, 2020.

$$\eta = \frac{V\,x\,I}{I_R\,x\,A_P} = \frac{P}{I_R\,x\,A_P} \quad (1)$$

Table 2. PV panel efficiency

Date	I_R (W/m^2)	PV Panel with perforated aluminum plates			PV Panel without perforated aluminum plates		
		V_1 (V)	I_1 (A)	η_1 (%)	V_2 (V)	I_2 (A)	η_2 (%)
January 21, 2020	639.5	20.1	0.46	2.12	19.6	0.30	1.35
February 4, 2020	425.1	16.4	2.0	11.29	15.7	1.6	8.65
February 5, 2020	351.8	17.34	1.38	9.95	16.05	1.07	7.14

High average solar radiation has resulted in low PV panel efficiency, so cooling media is needed below the PV panel. Installation of perforated aluminum plate cooling media has increased the efficiency of 100 Wp Polycrystalline PV panels. This perforated aluminum plate media has been useful to increase the efficiency of PV panels. In addition, how to make it simple, inexpensive, and easy to install.

4. Conclusion

A study has been carried out for 100 Wp Polycrystalline PV panels. The PV panel used consists of 2 units, each with a perforated aluminum plate cooler and without a perforated aluminum plate cooler. The diameter of this plate under study is 2.5 mm. Some concluding observations from the investigation are given below.

PV panels that use perforated aluminum plate cooler are better due to an increase in current and voltage output of PV panels compared to without perforated aluminum plate cooler.

The higher solar radiation received by the PV panel will increase the surface temperature of the PV panel but decrease the efficiency of the PV panel. For this reason, a cooling media is needed below the PV panel.

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