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Experimental Analysis of ACP on Photovoltaics as Free Convection for Increasing Output Power

Abstract. *This experiment uses perforated ACP as a cooling medium mounted on the back of a 100 Wp polycrystalline type photovoltaic panel, ACP with a hole diameter of 10 mm as passive cooling, which functions to reduce the temperature of the photovoltaic panel which has increased due to an increase in temperature. Radiation and excess heat from the Sun from 09.00 am to 15.00 pm, which is the peak of solar heat in subtropical areas such as Indonesia. The decrease in the temperature of the PV panels installed using the ACP cooler with a maximum of 9.13°C due to the free convection process will cause an increase in the maximum output power of the PV panel of 11.15 W.*

Streszczenie. *W tym eksperymencie zastosowano perforowany ACP jako czynnik chłodzący zamontowany z tyłu panelu fotowoltaicznego typu polikrystalicznego o mocy 100 Wp, ACP o średnicy otworu 10 mm jako chłodzenie pasywne, którego zadaniem jest obniżenie temperatury panelu fotowoltaicznego, która wzrosła ze względu na wzrost temperatury. Promieniowanie i nadmiar ciepła ze Słońca od 09:00 do 15:00, co jest szczytem ciepła słonecznego w obszarach podzwrotnikowych, takich jak Indonezja. Spadek temperatury paneli fotowoltaicznych zainstalowanych przy użyciu chłodnicy ACP o maksymalnie 9,13°C w wyniku procesu konwekcji swobodnej spowoduje wzrost maksymalnej mocy wyjściowej panelu fotowoltaicznego o 11,15 W.* (***Eksperymentalna analiza ACP w fotowoltaice jako konwekcja swobodna w celu zwiększenia mocy wyjściowej***|)

Keywords: Aluminum Composite Plate ACP, Free Convection, Passive Cooling, Polycrystalline
Słowa kluczowe: aluminiowa płyta kompozytowa, ogniwa fotowoltaiczne

Introduction

The photovoltaic panel is one of the semiconductor devices that functions as a means of converting sunlight into electrical energy. The characteristics of the photovoltaic panel (PV) are most influenced by the incidence of solar insolation temperature, shade, array configuration, and maximum tracking of the power point algorithm in generating maximum power from the panel. PV [1]. PV cells represent a serious breakthrough to compete with alternative fossil energy sources that are already low availability and likely to run out, generating electricity for environmentally friendly renewable and sustainable energy technologies [2]. Which is a renewable energy source. Indonesia is a subtropical area that is crossed by the equator so that the wealth of sunlight is abundant throughout the year [3].

The sunlight shining on the surface of the PV panel causes the temperature of the PV panel to increase; uncontrolled temperature rise have a negative impact on the output power. The simulation results show that the output power of the PV panels decreases with increasing working temperature, followed by efficiency. The output power generated by PV panels is influenced by atmospheric factors such as solar radiation and ambient temperature. These two factors significantly affect the temperature distribution of the PV panels. Increasing the temperature of the PV panel negatively affects the output performance of the panel [4]. A cooling medium is needed to maintain the temperature in order to get a better output power.

The cooling technique is a cooling method commonly used in PV panels, where the heat temperature of the PV panel is reduced through a heat transfer process to the cooling medium through conduction, convection, both by forced convection and by free convection [5].

Forced convection is a method of forced heat transfer rate by adding various additional equipment such as DC fan, spray water, flow water. Which is an active cooling which is very much researched by researchers, this method has the advantage of a highly heat transfer rate process when compared. However, free convection also has the disadvantage of adding additional energy used by the auxiliary equipment [6].

Researchers conducted an experiment to overcome the shortcomings of force convection by looking for other methods, namely free convection using a perforated Aluminum Composite Plate mounted under a PV panel with a hole diameter of 1.50 mm, to reduce the temperature of the PV panel naturally.

Methods

Cooling Technique

The cooling technique in PV cells introduces the difficulty of applying for heat transfer with varying heat transfer rates following the design of the Cooling strategy [7]. This Cooling strategy design requires high maintenance, and development may cost more than that of the benefits of increased electricity yield. The cooling technique design must be advantageous in high electric fields resulting in a decrease in heat temperature by up to several levels [8].

The cooling strategy used has the advantage of increasing electrical output. Cooling technique has two types of cooling system active and passive [9], active cooling which is often referred to as force convection which consumes externally power in the process of heat reduction (electric pump, dc fan and so on). The majority of passive or free convection cooling systems hot extraction occurs due to differences in working temperature convection or conduction

Active Cooling Methods

The cooling technique method in PV which consumes power continuously to reduce the temperature of the PV panel is an active cooling method that has been investigated experimentally [10], in this study it was carried out to cool PV cells actively, installing the inlet/outlet manifold in parallel for flow distribution. . air is installed uniformly on the back of the PV panel.

Active cooling uses a DC fan [11], a fan-induced forced convection cooling system as a cooling mechanism. A DC fan mounted on the back of the PV panel will extract the distributed heat energy and cool the PV panel. The DC fan working operation is controlled by the PIC18F4550 microcontroller, which depends on the average PV panel temperature value.

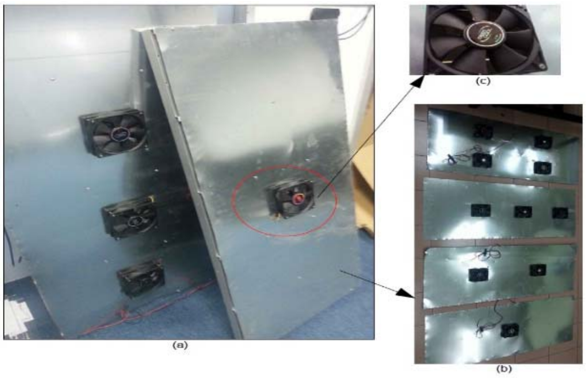

Fig 1. The development of DC fan cooling mechanism [11].

The cooling system is designed using pulsed spray water to increase the output power efficiency and reduce water consumption during the cooling process with a pulsed spray water system compared to a steady spray water cooling system and an uncooled photovoltaic panel [12].

Fig 2. Transmitting water from the pump to over the front of the cells [12].

The maximum electrical power output of the photovoltaic panels increased by about 33.3%, 27.7%, and 25.9% using spray water cooling, pulsed spray water cooling with DC = 1 and 0.2. Pulsed spray water cooling system with DC = 0.2 can reduce water consumption by up to one-ninth compared to fixed-flow cases [13].

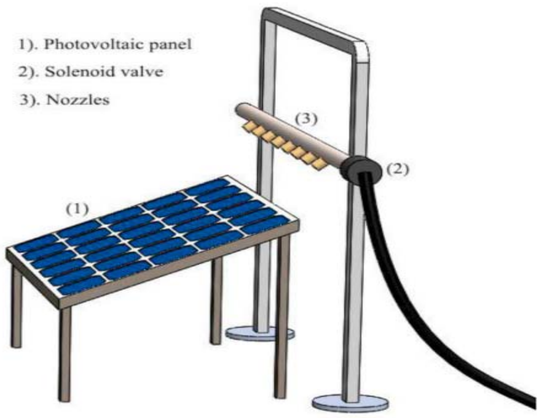

Fig 3. Schematic view of the PV panel with spray cooling system [13]

Passive Cooling

The passive cooling process is used to extract and/or minimize heat absorption from the PV panels without additional power consumption. The heat transfer rate mechanism of the PV panel is dissipated into the environment so that the heat temperature of the PV panel will automatically decrease.

Air passive cooling is one of the PV panel cooling techniques such as:

Cooling technique with passive cooling method uses an aluminium heat sink to remove waste heat from photovoltaic (PV) cells. The energy efficiency, exergy and power conversion of PV cells are greatly improved with the proposed cooling technique. A 20% increase in the power output of PV cells was achieved under the radiation conditions of 800 W/m^2. The maximum cooling rate is observed for the intensity level of 600 W/m^2 [14].

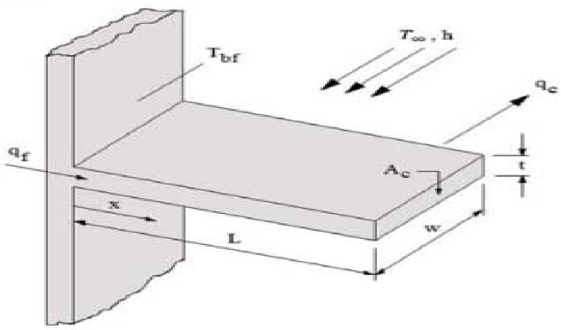

Fig 4. straight fins of uniform cross-section [14]

Various models of heat sinks are designed with different shapes of perforations to increase the contact area. Because it is a proven fact, the larger the contact area, the better the cooling. This point is kept in mind when designing the perforated slotted fin for analysis [15]–[19].

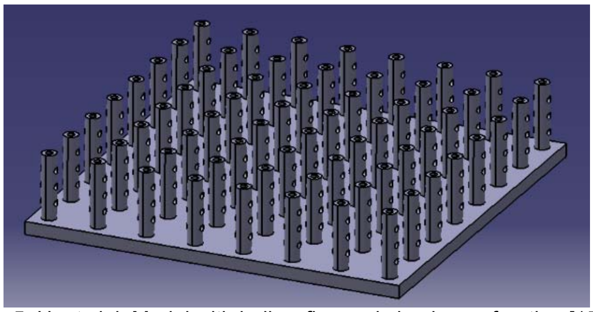

Fig 5. Heat sink Model with hollow fins and circular perforation [15].

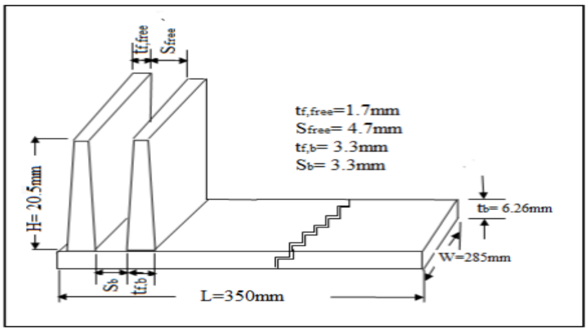

Fig 6. Heat sink parameters [16]

The free convection technique reduces the operating temperature of the photovoltaic module, which increases the efficiency and output power achieved by reducing the waste heat production or by increasing the waste heat rejection. Thermal modification most effectively reduces the waste heat production by reflecting unusable light from cells or modules [20]–[22].

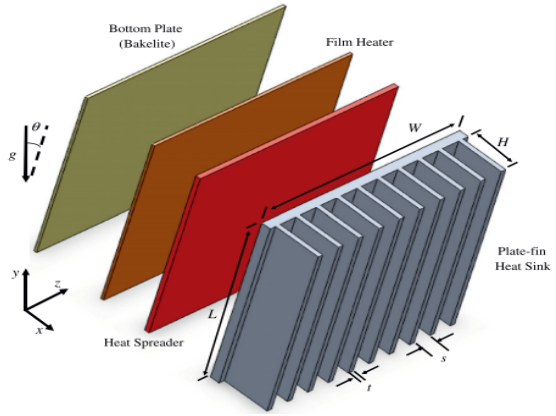

Fig 7. Schematics of tested plate-fin heat sink assembly [23].

Natural convection heat sink design with plate fins for centralizing photovoltaic module (CPV) coolant. Various heat sink geometries, input power, and tilt angle [23].

Several previous studies have carried out various experiments to reduce the temperature with the cooling technique method both actively cooling and passive cooling, so that a cooling method using ACP plates has been obtained as a contribution to science so it is important to conduct free convection experiments on PV using Perforated ACP.

Experimental Setup

Research Design

This experimental use of two units of polycrystalline 100 Wp photovoltaic panels with the same specifications are installed parallel, one of the panels is installed using ACP with a hole measuring 10 mm with a hole center distance of 20 mm as passive cooling with the rate of heat transfer by free convection.

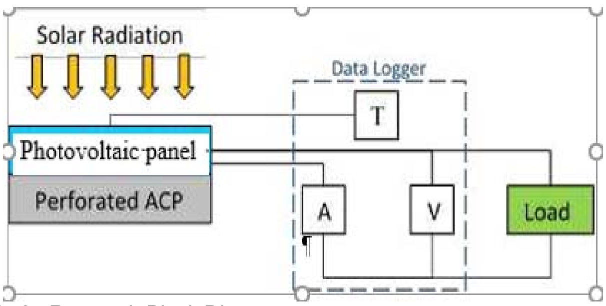

Fig 8. Research Block Diagram

Experimental outdoor polycrystalline photovoltaic with a capacity of 100 Wp with and without perforated ACP to test free convection in the open field using a data logger in the form of a data logger equipped with 4 temperature sensors installed at the top and bottom of the panel as well as installation of radiation sensors, voltage sensors to measure Voc and a current sensor to measure Isc. From the data logger connected to the computer via an SD card records temperature, current (Isc), voltage (Voc), and solar radiation automatically per unit time.

Computer data record, a data table can be made showing a decrease in the temperature of the PV panel using ACP, causing an increase in the output power of the PV panel using cooling due to free convection through the ACP hole.

Fig 9. Photovoltaic panels with and without Perforated ACP

Material ACP

ACP (Aluminum Composite Panel) is a cooling material that is installed on the back of one of the photovoltaic panels to reduce the temperature naturally without the addition of cooling aids, ACP has dimensions of 960 x 600 x 20 mm with 1515 holes.

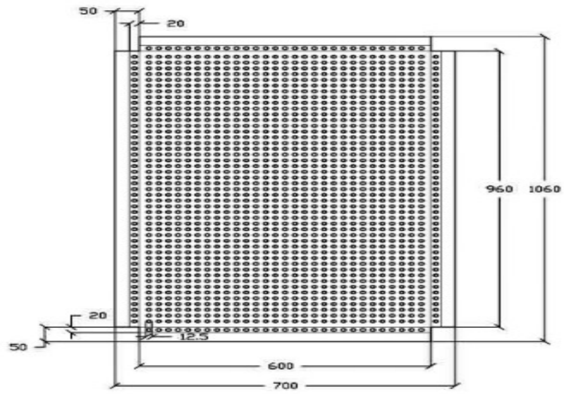

Fig. 10. Perforated ACP Prototype

Table 1. Demensions of perforate ACP

Name of Parts	Specification
Materials	Aluminum Composite Plate
Dimensions	960 x 600 x 20 mm
Hole Diameter	10 mm
Distance between holes	20 mm
Number of holes	1515
Arrangement of holes	Vertical-Horizontal

Photovoltaic Panel

100 Wp polycrystalline photovoltaic with the same specifications installed in parallel as shown in Figure 9, one of which uses ACP which is installed at the bottom of the PV panel as a cooling medium to test ACP performance in decreasing the temperature of the PV panel. The temperature sensor is installed at the panel. Whereas the voltage and the current sensor is mounted on the PV output.

Photovoltaic panel model GH100P-18V as shown in Figure 11.(c) has a maximum capacity of 100 Wp with a tolerance of 3%, Voltage at Pmax (Vmp) 18.30 V, Current at Pmax (Imp) 5.47 A, Open-Circuit Voltage (Voc) 22.5 V, Short-circuit Current (Isc) 5.91 A.

(a) (b) (c)

Fig. 11. Polycrystalline 100 Wp Photovoltaic Panel (a) front side, (b) backside, (c) specification

Experimental results

The measurement results of the temperature sensor in the data logger show that the photovoltaic panel obtains the highest temperature without ACP of 52.63°C, on the photovoltaic panel using ACP cooling of 43.50°C, a decrease in temperature is 9.13°C, as shown in Figure 12.

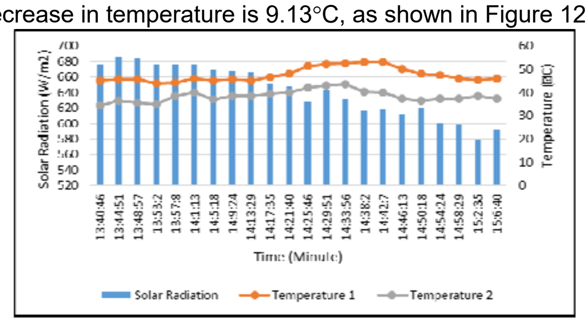

Fig. 12. Comparative performance of PV panel temperature and solar radiation

The highest current measurement results were obtained by a solar panel with a perforated ACP of 2.36 A, while a photovoltaic panel without a perforated ACP was 2.11 A shown in Figure 13.

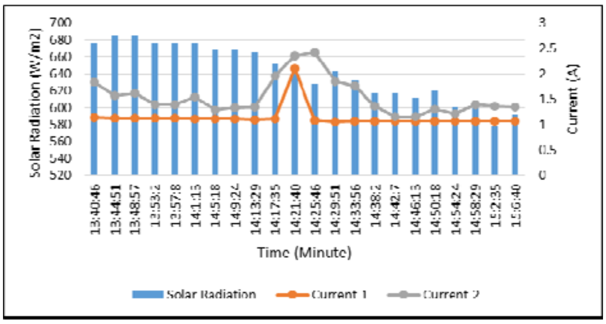

Fig. 13. Comparative performance of PV panel current and solar radiation

The measurement results obtained that the highest voltage was obtained by a photovoltaic panel using a perforated ACP of 16.39 V while a photovoltaic panel without a perforated ACP was 12.89 V shown in Figure 14.

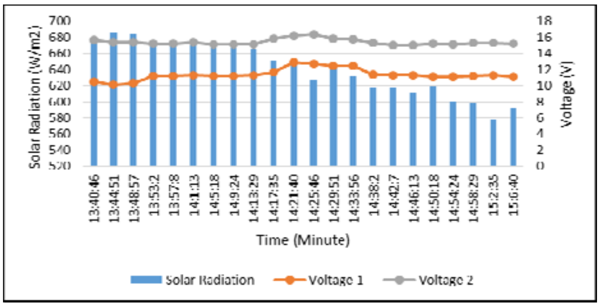

Fig. 14. Comparative performance of PV panel voltage and solar radiation

The highest output power calculation results were obtained by photovoltaic panels using perforated ACP at 38.35 W, while photovoltaic panels without perforated ACP were at 27.20 W shown in Figure 15.

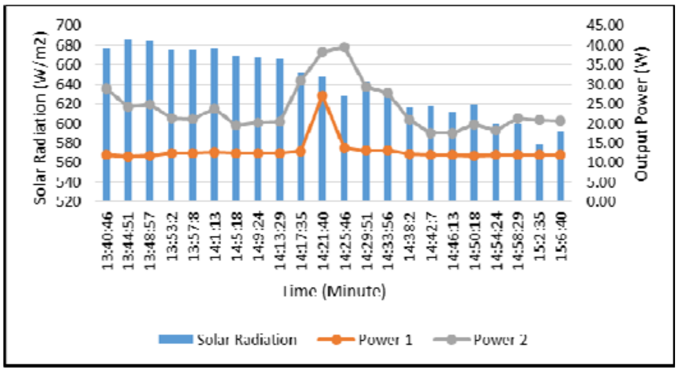

Figure 15. Comparative performance of PV panel output power and solar radiation

Conclution

The analysis of ACP experimental results on photovoltaic causes a decrease in the temperature of the PV panel by 9.13°C and an increase in output power of 11.15 W due to the free convection event that occurs with the rate of heat transfer from the PV panel to the outside and surrounding air.

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