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Saad Abdulquade Abdulaziz
University of Technology,
Baghdad, Iraq

Correspondence:
Saad Abdulquade Abdulaziz
University of Technology,
Baghdad, Iraq

Dust Impact on the Performance of PV Panels

Saad Abdulquade Abdulaziz

Abstract
Dust represents one of the important environmental parameters that effect photovoltaic (PV) performance. The accumulation of dust on the surface of a photovoltaic is natural. The accumulation dust can decreases the sunlight reaching the solar cell, performance of solar panels and losses the power generated. This studies show the result of accumulation duct how can reduce the generated power and performance of solar panels. The main object of this study is to see the effect of dust on the performance of PV panels.

Keywords: Photovoltaic, Dust effects, Solar Energy, Environment

1. Introduction

The phenomenon of climate change has become a reality affecting most areas of the globe and cause great suffering to the population of these countries [1, 2]. This phenomenon is one of the consequences of global warming, which some have refused to recognize for economic reasons in favor of large companies, the results of pollutants resulting from the burning of fossil fuels [3, 4]. What the earth has stored and manufactured from fossil fuels in millions of years has been consumed by most people in less than two centuries. Fossil fuels are destined to be depleted in less than a century [5]. The streets are flooded with cars, buses and heavy vehicles that emit millions of tons of air, water and soil pollutants that clearly affect human health and the quality of life they want [6, 7].

The trend towards the use of renewable energies in the production of electricity and the operation of cars and vehicles has become inevitable. In the case of cars, researchers are working on alternative fuels such as biodiesel [8, 9], bioethanol [10], hydrogen [11], and fuel cells [12]. In the production of electric power, there is a great focus on the use of wind power [13, 14], solar energy [15], geothermal energy [16], and wave energy [17]. Solar energy is the first target for researchers. It is clean energy and is available in most parts of the globe and is free. It is the sun can get the heat needed to generate warmth and electricity without contaminants [18, 19]. Applications of solar energy in heating water for domestic and industrial purposes are now available on a market basis and are used by a large number of consumers [20, 21]. Experiments on heating and heating the air using solar energy are promising [22, 23]. The Trombe wall is currently used in many homes and with high technical specifications and acceptable output [24-27]. The use of salty solar ponds has yielded promising results in providing heat in large quantities for household purposes, heating glasshouses or distilling water [28-30]. Solar distillation becomes a popular process in some communities [31].

Solar heat can be used to produce electric power using solar chimney [32, 33], concentrated power plants [34-37], and photovoltaic cells [38]. Photovoltaic cells are widely used in the domestic and industrial fields. The applications of these cells are begun to operate facilities in the desert or remote areas away from the network grid [39], to use in the operation of irrigation and watering systems [40, 41], and was used for lighting the streets [42, 43], the processing of parking by electricity and lighting [44], and the provision of electricity to communication stations [45].

Photovoltaic cells are clearly affected by external influences such as solar radiation [46], temperature [47], relative humidity [48], wind [49], and shadow [50, 51]. The accumulation

Of clouds of dust storms causes shadows that reduce the intensity of solar radiation reaching the cell and thus reduce its productivity [52]. The accumulation of dust and deposition on the surface of the cell is the second most effective factor of the resulting capacity after the temperature of the cell. Researchers have attempted to reduce the temperature of the cell by using PVT [53, 54], which works with air [55], water [56], nanomaterials [57, 58], and finally using phase-change materials with nanoparticles and nanotubes [59, 60]. Access to the ideal solution for rising cell temperatures seems very close [61-64]. But, the problem is that getting rid of the effect of the accumulation of dust on the surface of the cell is still early [65], despite the large number of research in this area [66-68].

Iraq is one of the countries that suffer from a lot of dust volatilities in their airspace and frequent dust storms in addition to the high pollution products of burning fossil fuels for the purposes of electricity production [69, 70]. In this study, we will try to evaluate the effect of dust accumulation on the PV module. We will try to the main factors influenced by this deposition.

2 Experiment Methodology

The aim of this study is to investigate the effect of dust on the Performance of PV Panels. The experiments are conducted by using 150W solar panel mounted on a stand. The solar panel module is made up of silicon cell has an area of 1 m^2. The dimensions of the panel are 1.5 m^2 by 0.65 m^2 by 0.005 m^2 thickness. The output electrical variables like voltage & current were measured to evaluate the effect of environmental dust. The impact of dust deposition can be determined by comparing between clean panel output and dusty one. The measurements of voltage and current were conducted using multimeters. A 65 W refrigerator was used as a resistor to achieve system's load. The experimental study is done in Baghdad city-IRAQ. The ambient temperature fluctuates in the range of 32 to 39 ºC during the test and temperature measure by using thermometer. The tests were conducted between 09:00 AM to 02:00 PM.

The rated power of the PV panel introduced by the manufacturers was 150W. Table 1 shoes the manufacturer rated values of the used PV module. During the tests, the PV panel was fixed at outdoor subjected to the atmosphere and accumulated dust was manually added to the panel surface. The effect of dust on the PV performance was determined by comparing the output current, voltage, and power of clean and dusty panels. The mass of dust was measured by digital weight balance and added on the solar surface 10 grams in each test. The tilt angle of solar panel was 30º and the panel was directed towards south to get maximum radiation from sun.

Table 1: Technical specifications of the used PV module at standard test conditions

Module type	MD-150-M
Maximum power (Pmax)	150W
Open circuit voltage (Voc)	21.96 V
Short circuit current (Isc)	9.11 A
Maximum power voltage (Vmp)	17.96 V
Maximum power current (Imp)	8.36 A

From the above table, to calculate the maximum output power, the maximum output current and maximum output voltage measured were used.

$$P_{max} = I_{max} \times V_{max} = 5.7 \times 13.6 = 77.52 \text{ W} \quad (1)$$

$$P_{max\ dust} = I_{max\ dust} \times V_{max\ dust} = 3.41 \times 12.5 = 42.625 \text{ W} \quad (2)$$

The PV panel's efficiency was calculated using the following relations:

$$\eta_{clean} = \frac{Pmax}{GA} = \frac{77.52W}{1000W\backslash m2 \times 1m2} \times 100 = 7.752\ \% \quad (3)$$

$$\eta_{dust} = \frac{Pdust}{GA} = \frac{42.625W}{1000W\backslash m2 \times 1m2} \times 100 = 4.2625\ \% \quad (4)$$

$$\%\ Reduction\ in\ output\ power = \frac{Pmax - Pmax\ dust}{Pmax\ dust} \times 100 \quad (5)$$

$$\%\ Reduction\ in\ output\ power = \frac{77.52 - 42.625}{42.625} \times 100 = 80.87\ \% \quad (6)$$

$$\%\ Reduction\ in\ module\ efficiency = \frac{\eta clean - \eta\ dust}{\eta\ dust} \times 100 \quad (7)$$

$$\%\ Reduction\ in\ module\ efficiency = \frac{7.752 - 4.2625}{4.2625} \times 100 = 82\ \% \quad (8)$$

Test Procedure

The accumulated dust was collected on a square-meter glass panel on its table in the outside air. Dust accumulated every day was collected and stores in dry containers away from moisture. After collecting a suitable quantity of dust, the dust was scattered with specific beams on the solar panel and shaken until the dust was distributed regularly. The next step was to measure voltages and current with changing electrical load.

During the study, we chose working days that have normal weather conditions as sunny with no storms. In fact, large losses in the module efficiency can be achieved if solar panels were exposed to dusty days. Although rain cleans the PV panels' surfaces and increase the generated power, but as the rain occurs occasionally and rarely in Baghdad, it cannot be relied on it for cleaning the system. To minimize the PV panels' efficiency loss, periodical cleaning is required.

Fig. 1 shows the tested PV panel after accumulated it with 300 grams of dust.

Fig. 1: the tested PV cell after being loaded by 300 gr of dust

3. Results and Discussion

The power output of photovoltaic units varies linearly with solar radiation [71]. During the study period, output power was decreased continuously due to accumulation of dust. The greater the mass of dust on the photovoltaic unit surface, the greater the loss of output power of the unit as shown in Fig 2. The output current is reduced by increasing the accumulation of dust on the PV then the current stabilized at a certain value. This means that there are limits to the effect of dust accumulation on the output current.

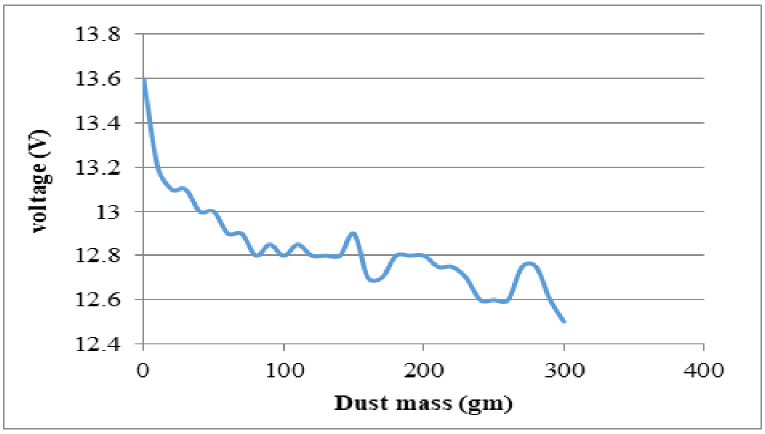

Fig. 2: the effect of dust accumulation on the output current

Fig. 3 shows the effect of dust accumulation on the resulting voltages. The output voltage has been reduced by increasing the amount of accumulated dust. There was variability in reading as shown in the figure, and this variability can be attributed to the wind effect that removes some dust from solar panels.

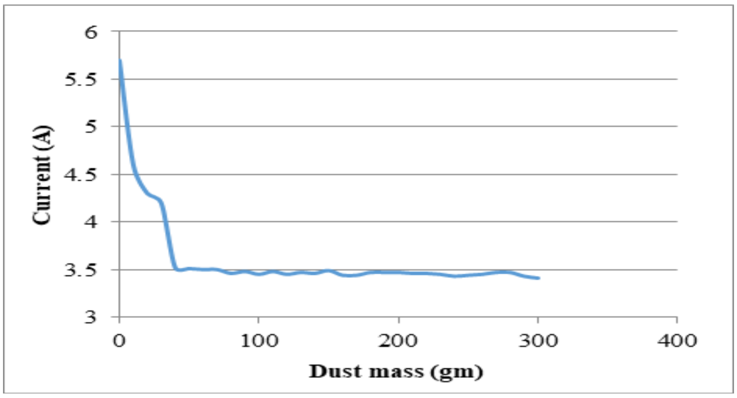

Fig. 3: the effect of dust accumulation on the output voltage

The PV panels' efficiency degrades with the dust accumulation on its surface. This efficiency depends upon the PV module's generated power of the solar irradiance intensity. Fig. 4 represents the effect of subjected load on the resulted voltage. The cell's voltage increased with increasing load to achieve the power needed to the load. The efficiency and power gradually decreased with the increase of dust mass deposited on the PV surface as show in equation (1), (2), (3), and (4).

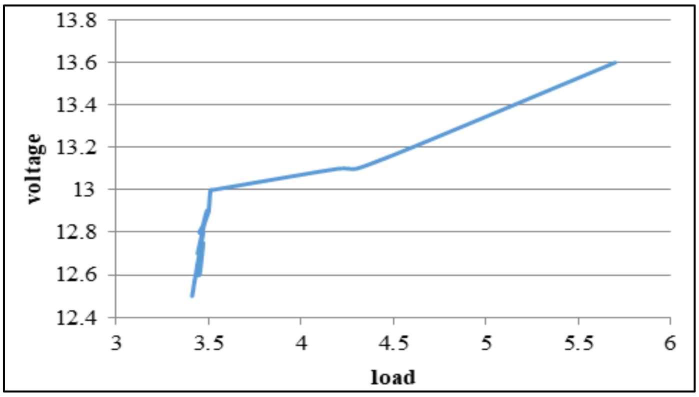

Fig. 4: the effect of subjected load on the PV's output voltage

Conclusion

In the current study, the impact of dust deposition on the performance of solar photovoltaic panel was studied experimentally when the PV module was subjected to outdoor environments. The study tried to estimate the effect of dust on the power and efficiency reduction. The resulted data manifests that rain are the most important factor that reduces the impact of dust accumulation on PV performance. The dust accumulation affects PV current and reduced it to a certain value, after this value it has no effect. The PV panel voltage is affected highly by dust accumulation. To reduce the dust influence on power and efficiency it is highly advised to clean the PV panel periodically. Also, the PV location can be considered as a very effective parameter in reducing dust deposition.

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