Experimental Comparison of Output Power Between Dusty and Non-dusty Photovoltaic Panels

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Abstract- Dust has a significant effect to preventing view and radiation transfer from source to recipient; Photovoltaic Solar Panels (PSP) used in producing electric power has its share of that effect as a result of blocking part of the solar radiation falling onto the photovoltaic solar panel which is considered as work principle of the photovoltaic solar panel. This research studies the effect of that dust on the photovoltaic solar panel via measured of voltage and current for both of dusty and non-dusty photovoltaic solar panel as well as output electrical power to compare between of them. Solar panels which used in this research is of type (Polycrystalline silicon solar Panels). Test data have been measured of a semi- shiny day in November at Iraq, Najaf city. Results has studied and analyzed to prove that electrical power of non-dusty (cleaned) higher than dusty photovoltaic solar panel that is mean cleaning of panels, is so necessary to get higher electrical power.

Index Terms- solar power, photovoltaic, solar PV, renewable energy, dust accumulation

I. INTRODUCTION

The energy demand rapidly increased due to industrial development as well as the increase in the world population. The rise in fossil fuel prices and its negative effect on human life and environment drew the attention to find alternative energy sources [1]. A lot of renewable energy sources can be utilized instead of fossil fuels such as solar, wind, and biomass energy due to its availability, ecological positive effect, and the relative low prices [2]. Solar energy can be utilized by using photovoltaic (PV) cells to convert the sunlight directly to electrical power. Despite the advantages of solar PV, it is still a challenge to maximize the power output of PV systems, mainly because of the limited efficiency of the cells. One of the factors that can influence the efficiency of a PV system is the accumulation of dust on the surface of the solar panel, especially in dry regions such as Middle East [3]. The accumulation of dust on the surface of the solar panel has a significant effect in reducing absorbed energy and this leads to decrease the power produced by the panels [4]. The Iraqi climate can be described as very hot and dry with frequently exposed to solar radiation. It is mostly desert-like with mild to cold winter and dry, hot, and cloudless summers, where dust storms hit and last for days [5].

Climate effects have been studied in many researches; [6] indicate that dust accumulation raises shade effects, preventing solar irradiation incidence on the panel surface. This could raise the heat inside the PV parts and reduce the efficiency of the photovoltaic cells. As a result, decrease their output power which reduces efficiency. Remarkable efforts were made to study the influence of deposited dust type on PV panel performance. For example, [7] experimentally investigated the dust effect on the energy performance of PV-panels. The study goal was to develop a theoretical model that could be applied easily with a reliable result related to the effect of natural air pollution on PV panels. Three types of common air pollutants were analyzed (red soil, limestone, and carbonaceous fly-ash). The results showed that the dust type and particle size reduce the efficiency of PV-panels. Likewise [8] numerically studied the effects of dust deposition on the performance of PV cells. The study aimed to present a model of prediction for the impact of dust particle sizes and the tilt angle of the PV on the generated power. The results showed the particle size, and the inclination angle has a significant effect on the PV efficiency. [9] Conducted an experimental investigation on the effect of the dust accumulation on the out power of solar PV. The experiments carried out in Sharqa, UAE, with both indoor and outdoor conditions. The characteristics of the dust particle and its effect on the PV performance have been studied. The obtained results showed that produced power effected by the dust presence. Moreover, when the dust density was high, the short circuit current reduced significantly. It was concluded that the tilt angle plays a significant role as dust removal by gravity.

Likewise,[10]studied the effect of dust accumulation on the output power of the solar PV system. The investigation conducted on two different technologies in Dhahran, Saudi Arabia, that frequently exposed to dust storms. The result showed that the generated power decreased by 50% for the solar PV left unclean for six months. Moreover, the use of solar tracker enhances the produced power and decrease the dust effect by 50%.

Numerous attempts were made to concentrate on climate conditions and dust accumulation impact on PV panel performance. [11] Conducted an experimental study concerning the effect of dust storms on the performance of the photovoltaic modules. The obtained result compared with the one corresponding to normal weather and with the calculation obtained by a theoretical model. It was concluded that the presence of the dust on solar PV reduces the output power, which reduces the system efficiency. The degradation rates in the efficiency are 6.24%, 11.8%, and 18.74% calculated for periods of a day, a week, and a month.

[12] Examined dust effect on a PV system performance and estimating the power reduction during the test period. The experiment conducted at Shahid Beheshti University, Tehran, Iran, for 70 days. The obtained results showed that the reduction in the power generation of the solar PV caused by the dust accumulation was 21.47% along the test period.

Likewise, [13] experimentally investigates the effect of dust and weather conditions on the performance of solar PV. The study conducted in Tehran, Iran, were two solar PVs had been used. One of them was cleaned every day, and the other left any cleaned for 45 days. The results showed that the power generated by the unclean solar PV reduced about 8-12% per month. It was concluded that dust accumulation has the most effective variable among tested conditions. The aim of current work is to investigate the effect of dust accumulation on the output power and efficiency of the solar panel in the dry and desert areas, specifically the city of Najaf.

II. MATERIALS AND METHODS

The solar panel used in this study is Poly-crystalline silicon. Located in Iraq - Najaf city at GPS coordinates (31.993612.N 44. 355649.E). Two solar panels were used from a set of solar panels used to operate the water pumping system. The information on the PV panel is shown in the table (1).

Location	Iraq / Najaf city
Latitude and longitude	31.993612.N 44.355649.E
Panel dimensions	(54*120) cm
Type of solar panel	Poly-crystalline silicon
Tilt angle	60˚with horizon
Orientation	32˚

Table (1) Information of PV panels.

To have reliable results, the experiment data collected by testing two solar PV panels simultaneously, at the same time, under the same weather conditions. The first solar panel was unclean, while the other one was clean, as shown in Fig (1).

Fig. 1 Solar panel system.

The experiment was held in November in an almost clear day for every ten minutes from 10 AM to 4 PM. The intensity of solar radiation was measured using KIMO pyranometer SL-200 Solarimeter with 5% accuracy. The output power (the output current and voltages) of the solar panel measured using a FLUKE Digital Multimeter Model 77 IV with 3% accuracy in conjunction with measuring the intensity of solar radiation. The ambient temperature measured by using K- type thermocouple connected to a digital thermometer; hence all the above instruments were tested and calibrated before the experiment.Fig.2. shows a schematic diagram for the experiment setup.

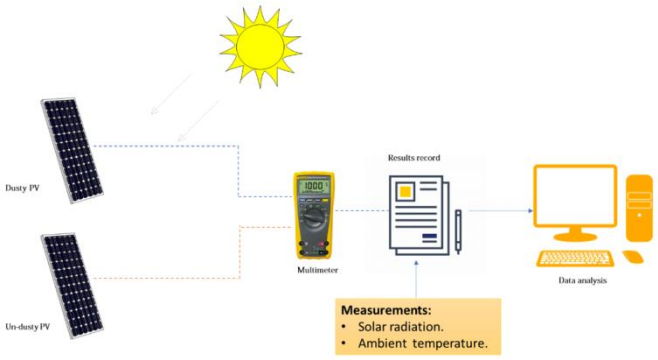

Fig.2. A schematic diagram for the experiment setup.

Based on the above and the technical data of the solar panel shown in Table (2), the results were obtained and analyzed for both non-dusty and dusty solar panels and determining the impact of dust on the value of processed capacity and efficiency.

Peak Power (Pmax)	80	W
Warranted Minimum (Pmax)	72	W
Voltage (Vmp)	33.3	V
Current (Imp)	2.4	A
Open Circuit Voltage (Voc)	41.5	V
Short Circuit Current (Isc)	2.6	A

Table (2) Technical data of the solar panel.

III. RESULTS AND DISCUSSION

As mentioned before that to determine the effect of dust accumulation on the output power of PV panels, the experiment was carried out, by comparison, the performance of two identical pairs of PV panels. One of the PV cells has been cleaned, while the other has not been cleaned for more than four months. Both solar panels tested at the same atmospheric conditions, tilt, and orientation angle.

Fig.3 shows the voltages generated by the non-dusty solar panel during the test period, ranging from 32.8 to 42.28 volts, with the lowest voltage at 11:30am and the highest voltage at 11:10am.

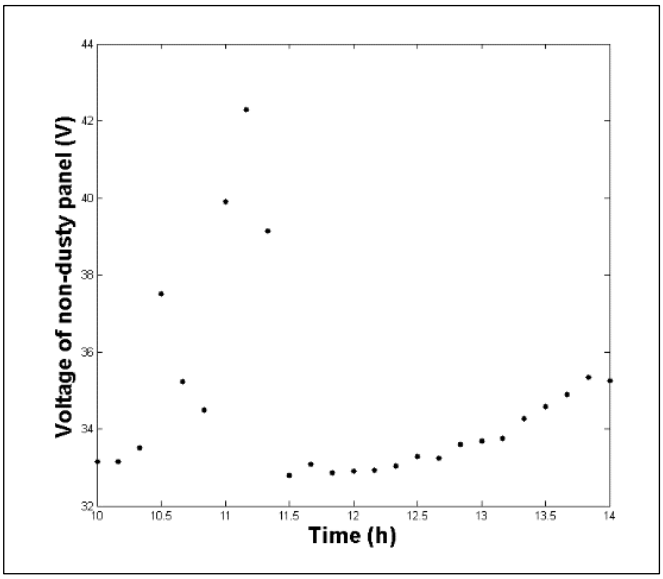

Fig .3 Illustrates the voltages generated from the non-dusty solar panel.

Fig. 4 shows the voltages generated by the dusty solar panel during the test period itself, it ranged between (33.28-41.88) volts. The lowest reading of the voltages was at 11:40 am, the maximum reading of the voltages recorded at 11:10 am.

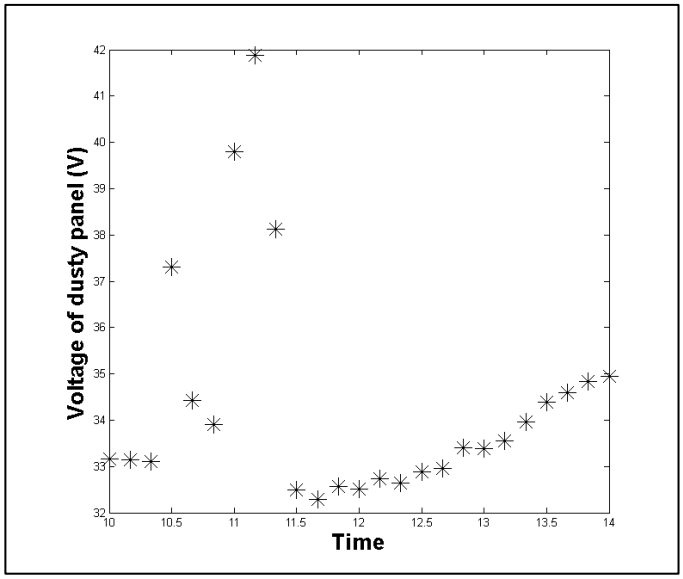

Fig.4 Illustrates the voltages generated from the dusty solar panel.

To compare between the voltages produced by the non-dusty and dusty panels, Fig 5 shows the voltages generated during the same test period. It is observed from the fig that the non-dusty solar panel voltage is higher than the voltage of the dusty solar panel with a voltage loss ranging from 0.1 to 1.0 volts, the reason is due to preventing part of the solar radiation falling on the surface of the cell forming the solar panel.

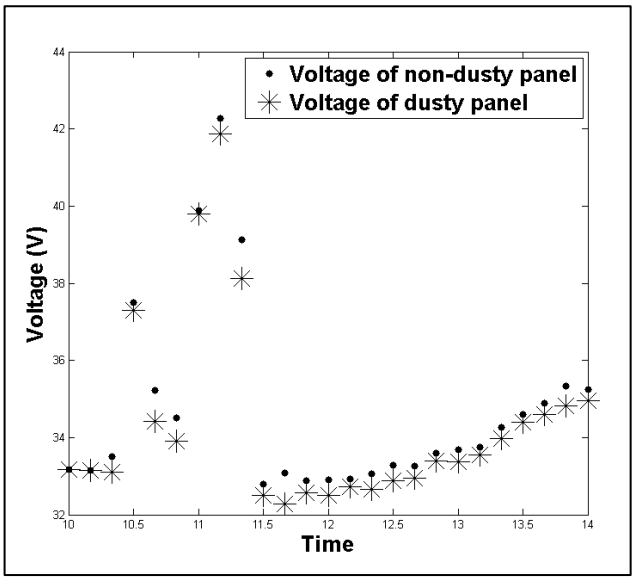

Fig.5 Illustrates the voltages generated from the dusty and non-dusty solar panels.

As for the current, Fig. 6 shows the current of the solar panel during the measurement period, which ranged between (1.68) amps at 10:00 pm and (2.59) amps at 12:40 pm.

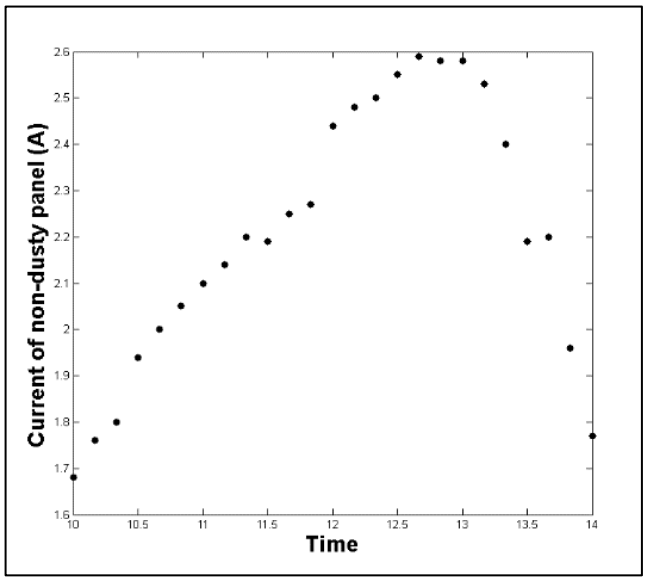

Fig.6 Illustrates the current generated from the non-dusty solar panel

Fig.7 shows the current resulted from the dusty solar panel during the same period, which was the

highest (2.24) Amp at (12:40 - 12:50) pm. Also, it was as low as it was equal to (1.44) amp at 10:00 am.

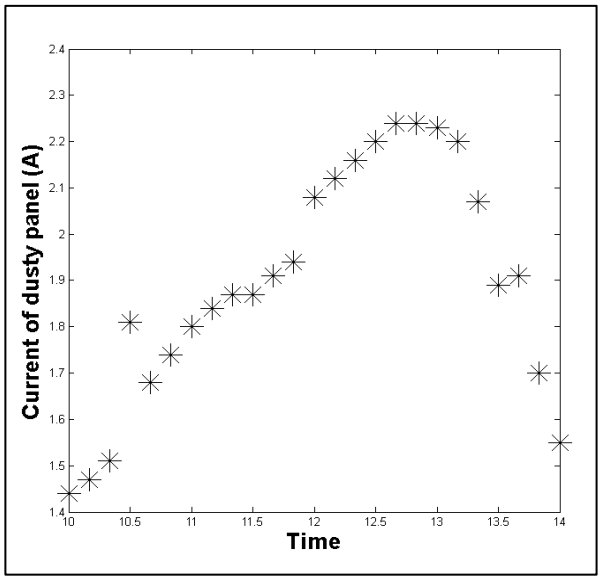

Fig. 7 Illustrates the current generated from the dusty solar panel.

For the purpose of comparison between the current produced from the non-dusty and dusty panels, it is noticed in Fig. 8 that there is a clear difference between the current supplied from the panels during the time of the test, the current of the dusty panel was less than the current supplied by the non-dusty panel, it is ranged between (0.13 - 0.36) amp.

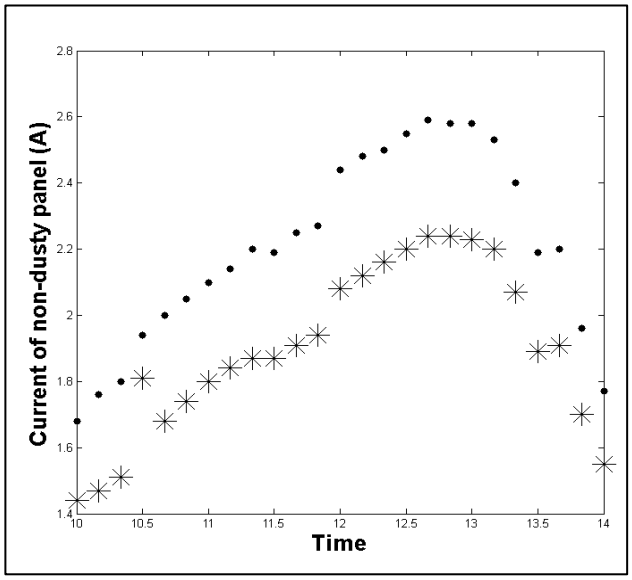

Fig. 8 Illustrates the current generated from the dusty and non-dusty solar panels.

Thus, the electrical power of the dusty solar panel was less than the electrical capacity of the non-dusty solar panel over the duration of the test and at a rate of (5.24 – 14.78) watts, as shown in Fig. 9.

Then, the efficiency of the solar panel was negatively affected by the deposition of volatile dust in the atmosphere on the surface of the panel, the loss of efficiency ranged from (1.01 – 3.18) %. Thus, maintaining the cleanliness of the solar panel is essential to obtain the greatest possible power and thus benefit more from the use of this type of systems.

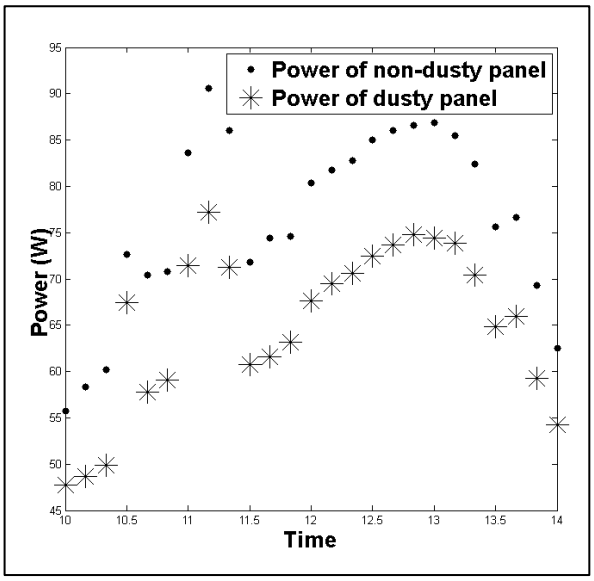

Fig. 9 Illustrates the power generated from the dusty and non-dusty solar panels.

IV. CONCLUSIONS

This study has reached important results for the solar panels in terms of the deposition of dust on the surface as well as the efficiency of this type of systems and compared with the design efficiency of solar panels in general, and it is used in the Al Sook district in particular. The following was concluded:

1. The non-dusty solar panel voltage is higher than that of the dusty solar panel with a loss of voltage ranging from 0.1 to 1.0 volts. This is due to the blocking off part of the solar radiation falling on the surface of the solar cell.
2. There is a clear difference between the current of the panels during the time of the test, since the current of the dusty solar panel was less than the current supplied by the non-dusty solar panel and the difference was between 0.13-0.36 amp.
3. As a result of the difference in the amount of voltages and current currents obtained from this study, the electrical power of the dusty solar panel was less than the electrical power of the non-dusty solar panel over the duration of the test at a rate ranging from (5.24 – 14.78) watts.
4. Maintaining the cleanliness of the solar panel is essential in order to obtain the highest possible power and to achieve higher efficiency and thus benefit more from the use of this type of systems.

REFERENCES

[1] M. Z. Jacobson and M. A. Delucchi, "Providing all global energy with wind , water , and solar power , Part I : Technologies , energy resources , quantities and areas of infrastructure , and materials," Energy Policy, vol. 39, no. 3, pp. 1154–1169, 2011.
[2] M. S. Almadhhachi, M. H. MacHi, and M. F. Jaber, "Enhancement of charging system for electrical vehicle using PV panels," J. Mech. Eng. Res. Dev., vol. 43, no. 4, pp. 223–229, 2020.
[3] C. Fountoukis, B. Figgis, L. Ackermann, and M. A. Ayoub, "Effects of atmospheric dust deposition on solar PV energy production in a desert environment," Sol. Energy, vol. 164, no. February, pp. 94–100, 2018.
[4] M. Mani and R. Pillai, "Impact of dust on solar photovoltaic (PV) performance : Research status , challenges and recommendations," Renew. Sustain. Energy Rev., vol. 14, no. 9, pp. 3124–3131, 2010.
[5] A. A. Kazem, M. T. Chaichan, and H. A. Kazem, "Dust effect on photovoltaic utilization in Iraq: Review article," Renew. Sustain. Energy Rev., vol. 37, pp. 734–749, 2014.
[6] A. Pandian, K. Bansal, D. J. Thiruvadigal, and S. Sakthivel, "Fire Hazards and Overheating Caused by," Fire Technol., vol. 52, no. 2, pp. 349–364, 2016.
[7] J. K. Kaldellis and M. Kapsali, "Simulating the dust effect on the energy performance of photovoltaic generators based on experimental measurements," Energy, vol. 36, no. 8, pp. 5154–5161, 2011.
[8] H. Lu and W. Zhao, "Effects of particle sizes and tilt angles on dust deposition characteristics of a ground-mounted solar photovoltaic system," Appl. Energy, vol. 220, no. March, pp. 514–526, 2018.
[9] A. A. Hachicha, I. Al-Sawafta, and Z. Said, "Impact of dust on the performance of solar photovoltaic (PV) systems under United Arab Emirates weather conditions," Renew. Energy, vol. 141, pp. 287–297, 2019.
[10] M. J. Adinoyi and S. A. M. Said, "Effect of dust accumulation on the power outputs of solar photovoltaic modules," Renew. Energy, vol. 60, pp. 633–636, 2013.
[11] M. Saidan, A. G. Albaali, E. Alasis, and J. K. Kaldellis, "Experimental study on the effect of dust deposition on solar photovoltaic panels in desert environment," Renew. Energy, vol. 92, pp. 499–505, 2016.
[12] A. Gholami, I. Khazaee, S. Eslami, M. Zandi, and E. Akrami, "Experimental investigation of dust deposition effects on photo-voltaic output performance," Sol. Energy, vol. 159, no. August 2017, pp. 346–352, 2018.
[13] H. Salimi, A. Mirabdolah Lavasani, H. Ahmadi-Danesh-Ashtiani, and R. Fazaeli, "Effect of dust concentration, wind speed, and relative humidity on the performance of photovoltaic panels in Tehran," Energy Sources, Part A Recover. Util. Environ. Eff., vol. 00, no. 00, pp. 1–11, 2019.

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