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The Impact of Dust Accumulation on the PV Panels Outcomes

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Abstract— **One of the vital natural parameters that impact photovoltaic (PV) execution is dust deposition. 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 study's results clarified that rain I natural cleaner of dust. Also, dust accumulation depends mainly on the PV arrays site. For this purpose, The PV module location must be selected carefully.**

***Index Terms*— Photovoltaic, Dust effects, Solar Energy, Environment, Baghdad city**

I. INTRODUCTION

The PV sun based power speaks to a standout amongst the most encouraging renewable vitality on the planet [1]. The innovation of Photovoltaic PV is dependably on constant creating in numerous applications, so it is produce power without perilous impact on environment [2]. The power produced from daylight is called sun powered power and the way toward changing over sun based light into power is known as the photovoltaic procedure [3]. In this Process, coordinate current (DC) power is delivered. Edmund Becquerel, a French researcher in 1839 found power because of photovoltaic impact yet effectiveness is low [4].

The yield of PV is appraised by producers under Standard Test Conditions (STC), which is, the temperature = 25ºC; sunlight based irradiance (force) = 1000 W/m^2, and solar air mass= 1.5 [5]. These conditions are effectively reproduced in a manufacturing plant however the circumstance is diverse for open air [6]. With the expanding utilization of PV frameworks, it is essential to assess the impacts of the dynamic meteorological parameters, for example, stickiness, tidy, temperature, and wind speed on the PV framework's proficiency [7]. However, Iraq is characterized by frequent dust storms and so many dusty days, which recurs most of the days of spring and autumn [9]. Two decades of continuous drought, and the movement of military vehicles in the three wars within the territory of Iraq has caused this country to convert west side of it to a source of sand basin [10]. This basin influences Iraq's neighbors in an uneven manner, but the cities of Iraq are all affected by it. In spite of all that, many studies have shown that the potential of using solar cells are available with the need to clean the cells continuously [11].

This research was conducted to study the effect of dust accumulation on PV system performance and compare with a clean one. This paper is a fruit of a continuous effort from the Energy and Renewable Energies Technology Center, University of Technology, Baghdad, Iraq to explore the possibilities of using PV systems in Iraq climate conditions [12-37].

II. EXPERIMENTAL WORK

The question of this paper was to explore the impact of clean on the execution of PV boards. The examination was led by utilizing 150W sun powered board mounted on a stand. Table 1 lists the used PV panels' specifications. 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. The electrical parameters like voltage and current have been measured to concentrate on the impact of ecological clean.

The effect of dust can be known by comparing between a polluted and dusty panel and a clean one. The multi-meters were used to measure the voltage and current. The system's was loaded using a (65W) refrigeration resistor. The test study is done in the University of Technology, Iraq. The latitude and longitude of the area are 33.2232° N, 43.6793° E. The surrounding temperature varies in the scope of 32 to 39 ºC amid the testing time; the temperature measured using thermometer. The tests were dune between 09:00 AM and 02:00 PM. The manufacturers rated power of module was 150W. The manufacturer rated values of modules are shown in Table 1. During the study, the outdoor panel was under the outdoor climate conditions, and an accumulate dust was added manually on the panel surface with fraction rates of 10 gram each step. The effect of dust was determined by comparing the output parameters of clean and polluted panels. The mass of dust was measured by digital weight balance and added on the solar surface 10 grams in each test. The tilde angle of solar panel was kept 33º and the phase of solar was on south to get the maximum radiation from sun.

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Table 1. The used PV panels specifications

Module type	ND-150-M
Open circuit voltage(V_{oc})	21.96 V
Short circuit current (I_{sc})	9.11 A
Maximum power (P_{max})	150W
Maximum power voltage (V_{mp})	17.96 V
Maximum power current (I_{mp})	8.36 A
Limited output guarantee	25 years

III. Results and Discussion

The data of solar panel outcomes were recorded during the test as Table 2 indicates. . The yield force of PV modules differs straightly with the sun based irradiance. Over the time of study, the yield force of modules diminished persistently because of clean gathering. As the clean mass on the surface of PV module increment, the loss of module yield current and voltage got to be higher, as show in figures 1 and 2. The effect of accumulated dust on output power is illustrated in figure-3. The output current was affected by increasing the dust accumulation on PV until the power reached the steady state at dust weight of 90 grams, after this dust fraction the reduction in output power was limited. There is a limit for dust accumulation effects on the output current. Also, the output voltage was affected by increasing the dust accumulation on PV, but with increasing rate. There was fluctuation in the voltage reading as figure-2 shows. This fluctuation was due to wind effect that removed some dust from the solar panel.

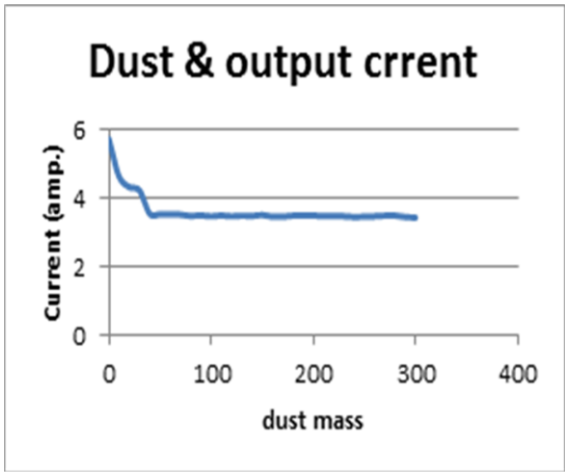

Fig. 1. The effect of dust accumulation on the tested PV current

The maximum output power was calculated using measured maximum output current and maximum output voltage.

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

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

Following relation was used for the calculation of module efficiency.

$$\eta_{clean} = \frac{P_{max}}{GA} = \frac{77.52W}{1000W\backslash m^2 \times 1m^2} \times 100 = 7.752\ \% \quad (3)$$

$$\eta_{dust} = \frac{P_{dust}}{GA} = \frac{42.625W}{1000W\backslash m^2 \times 1m^2} \times 100 = 4.2625\ \% \quad (4)$$

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

$$\%\ Reduction\ in\ module\ efficiency = \frac{\eta_{clean} - \eta_{dust}}{\eta_{dust}} \times 100 \quad (6)$$

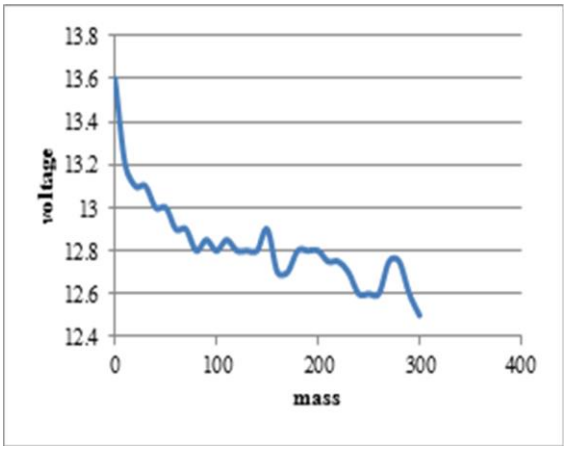

Fig. 2. The effect of dust accumulation on the tested PV voltage

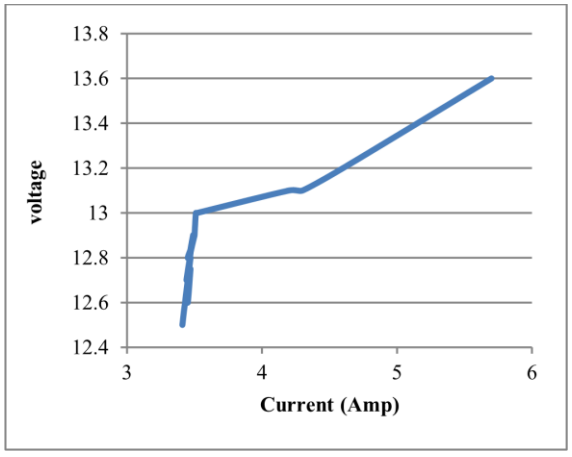

Fig. 3. The relation of I and V when dust accumulated on the tested PV current

The module effectiveness relies on the yield force of PV module and sun oriented irradiance and both were debased with the clean aggregation on PV module surface. The module proficiency demonstrated a reverse connection with the sun powered irradiance and module temperature. At the beginning, the efficiency of PV was high. The efficiency and power gradually decreased with the increase of dust mass deposited on the PV surface as show in equations 1, 2, 3 and 4.

During the study, the weather conditions were normal as most days were sunny with no high wind speeds. In fact, there would have been quite a large loss in module power if the PV panels were put in dusty areas. Although rain causes the cleaning of module and increase output power, it cannot be relied on it for cleaning purposes as the rain occurs occasionally in Iraq and in the winter season only. The PV modules thus require regular cleaning to minimize the efficiency loss.

IV. Conclusion

In this paper, the execution of sun based photovoltaic board subjected to a few tidy masses was tentatively concentrated on. The impact of tidy on the power diminishment and proficient decrease of PV module was evaluated. The data suggests that rain is the most important factor that prevents the power degrading because of dust accumulation is. Rain tends to do a pretty good job cleaning off the PV modules. The next most important factor is location. Therefore, each selected location needs to be evaluated for dust accumulation capabilities.

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Table 2, the tested polluted and dusty PV panel's data

Test No.	Mass (gram)	Load from PV (Ambere)	Voltage from PV (volt)	Test No.	Mass (gram)	Load from PV (Ambere)	Voltage from PV (volt)
0	0	5.7	13.6	16	160	3.44	12.7
1	10	4.6	13.2	17	170	3.44	12.7
2	20	4.3	13.1	18	180	3.47	12.8
3	30	4.2	13.1	19	190	3.47	12.8
4	40	3.52	13	20	200	3.47	12.8
5	50	3.51	13	21	210	3.46	12.75
6	60	3.5	12.9	22	220	3.46	12.75
7	70	3.5	12.9	23	230	3.45	12.7
8	80	3.46	12.8	24	240	3.43	12.6
9	90	3.48	12.85	25	250	3.44	12.6
10	100	3.45	12.8	26	260	3.45	12.6
11	110	3.48	12.85	27	270	3.47	12.75
12	120	3.45	12.8	28	280	3.47	12.75
13	130	3.47	12.8	29	290	3.43	12.6
14	140	3.46	12.8	30	300	3.41	12.5
15	150	3.49	12.9				

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