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THE INFLUENCE OF DUST DENSITY AND ITS GRAIN SIZE ON THE POLYCRYSTALLINE PV PANEL ELECTRIC POWER PRODUCTION

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Abstract - Polycrystalline PV is one of the most solar cell types available in the market for domestic use due to its cost and its favorable efficiency. The output electrical power generated using polycrystalline PV cells depends on many parameters including the dust covered its surfaces during use. This research investigates the influence of dust grain size and its density on the output power produced using Polycrystalline PV panel. Three different of dust grain size and densities are tested in Al-Hussein Bin Talal University mining laboratory under steady conditions, then used to covered polycrystalline PV panel with different densities. maximum output power is measured at simple resistive load once the panel not covered with dust, this experiment repeated three time and the output power reduction is measured three times when the panel is covered with three types of dust with different grain size. There is inversely relationship with dust grain size covered the panel and the maximum output generated, furthermore, there is proportional relationship between the dust density and the output power generation, this results will open the door in front of solar farms using polycrystalline PV panels in different areas in taking an actions in cleaning process at specific times depend on environmental conditions at that area.

Keywords - Polycrystalline PV; Maximum Output Power; Solar Cell; Dust Grain Size.

I. INTRODUCTION

Environmental dust is One of the most important factors that affect the solar panels efficiency [1], physical properties such as dust size, shape and weight, chemical, and Other factors related to the environmental conditions; such as site-specific factors, environmental features and weather conditions [2].Normally, the dust covers the panel surface area will reduce the amount of solar light or radiations penetrate to the panel surface [3][4][5], increasing the amount of light scattered from the panels [6][7][8], and finally reduce the panel efficiency [9] [10] [11].
The maximum electric power (Pmax) and the power conversion efficiency (η) are the most common indicators for PV solar cells [12]. Formulas 1and 2 below are used to calculate these factors [13].

$$P_{MAX} = V_{mp} \times I_{mp} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\eta = \frac{P_{MAX}}{E_{TOT} \times A} \times 100\% \qquad (2)$$

Where the Vmp is the voltage at the maximum power point, Imp is the current at the maximum power point, A is the panel area, and ETOT is the total incident irradiance under standard test conditions (STC) in (W/m2).
According to grain size, the dust could be classified into fine, medium and coarse grain, which is vary from less than 0.05 mm up to 57 mm [14]. This study is to evaluate the effect of dust on the performance of Polycrystalline PV panel. The effect of dust was classified according to the dust grain size, and its density (g/m2).

II. METHODOLOGY

The study takes place at Al-Hussein Bin Talal University; which located in a high annual direct irradiation city in southern part of the country (Ma'an), at latitude 30.2° and longitude 35.4°. In this study the attention was given to evaluate the effect of different dust mass density and grain size distribution on the panel.

In this work :monitoring system, basic electronics trainer M30 kit, Two digital multimeters(DM)-9080, 100W halogen lamp as a light sourcewith zero tilt angle,polycrystalline PV panel was used. Table 1 below shows A polycrystalline PV panel electrical specifications.

Polycrystalline Silicon	
P_{max}	1.85W
V_{mp} (voltage at the maximum power point)	13.5V
I_{mp}(current at the maximum power point)	13.7mA
V_{oc} (open circuit voltage)	19V
I_{sc} (short circuit current)	16.5mA
Panel dimensions	33X25mm

Table 1: Polycrystalline Electrical Specifications

Figure 1 below illustrate the schematic diagram for polycrystalline PV panel test, variable resistor load used to measure the output polycrystalline PV panel currents and voltage. Without any dust covered the solar panel surface, and the same tests conditions

including the temperature, pressure, humidity, irradiance source and tilt angle; the output currents, voltage, and power are measured at the variable resistor.

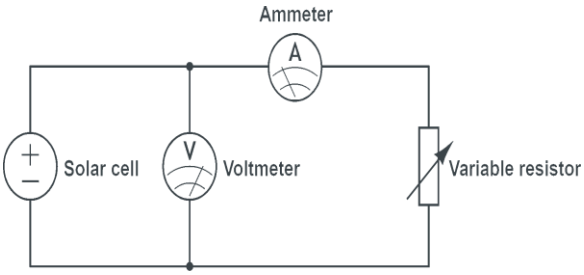

Figure 1: PV panel test circuit Schematic diagram

The three dust samples have been collected from different locations in Alhussien bit Talal university (AHU),dried using oven, and tested in mining laboratory to find the exact dust grain size components in each sample. using rifle box, Different sieve opening sizes were used to classify the dust grain according to their sizes. Fixed dust mass about 1500 g were used during each experiment. each sample are spreads at the polycrystalline PV panel at different dust density and the outputcurrents, voltage and power are measured again at the variable resistive load. The maximum output powers from the panel for each sample were measured andthe reduction in output power are calculated to observe the relationship between dust grain size and its densities with the output power generated.

III. EXPERIMENTAL RESULTS

Figure 2 below shows the I-V Curve for Polycrystalline PV panel without using dusts to cover the surface panel. furthermore, table (2) below shows the measured output currents, voltage and calculated power at the variable resistor load.

Figures 2 shows the I-V curve for the Polycrystalline PV panels.here the maximum output power which is the point of interest are measured at the short circuit current I_{SC} and open circuit voltage VOC,where the I-V curve or the currents is fall from larger value to very smaller values suddenly at the knee in I-V curve. Where the max output power is 1.85W Occurs at output currents of 13.7 mA and 13.5 V respectively. In this experiments the output voltage keep increasing due to the nature of the Polycrystalline PV panel and the radiation come from the halogen Lampe, since the radiation increased during the experiment time, the voltage keep increasing. on the other hand, the currents decreased due to the impedance of the resistive load.

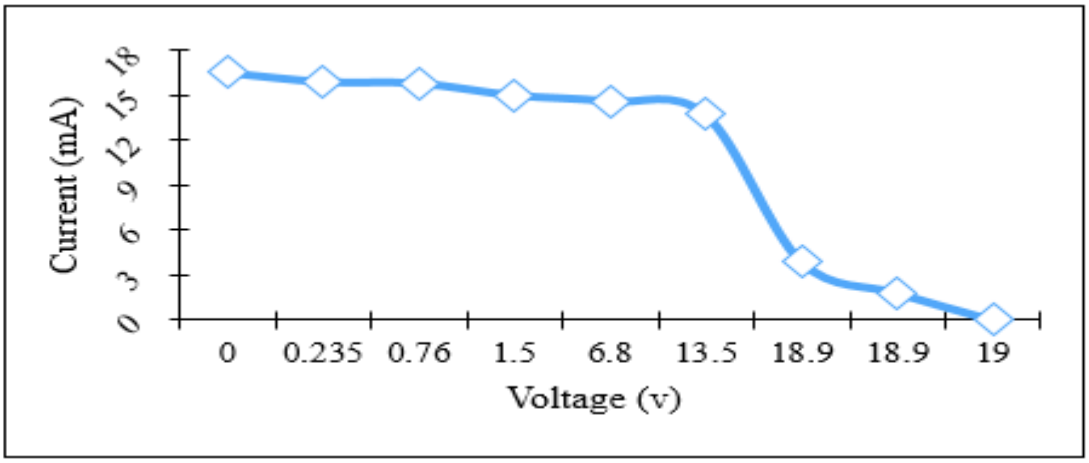

Figure 2: I-V Curve for Polycrystalline PV panel

Voltage (V)	Current (mA)	Power (W)
0	16.5	0
0.235	15.9	0.037
0.76	15.8	0.12
1.6	15	0.30
6.8	14.6	0.99
13.5	13.7	1.85
18.9	3.9	0.737
18.9	1.8	0.34
19	0	0

Table 2: The panel output current, voltage and power.

The dust samples grain ranges were classified according to the sieve opening in(mm). For each dust sample, the percentages of dust distribution according to the grain size were given in Table 3 below.

Sieve Opining (mm)	Mass retained in the sieve					
	Sample 1		Sample 2		Sample 3	
2-19	398.45g	26.61%	248.45g	16.60%	288.01g	19.23%
0.05-2	648.50g	43.30%	577.70g	38.57%	603.40g	40.29%
<0.05	450.60g	30.10%	671.40g	44.83%	606.14g	40.48%

Table3: Grain Ranges for the Three Dust Samples

As shown in Table 3, each dust sample were classified to coarse, medium and fine with grain size (2-19mm, 0.05-2mm, and <0.05mm) respectively [15]. it is observable that the first sample has the larger percentage of coarse dust grain (26.61%) and less percentage of fine grain (30.10%). While the second sample has the finest grain dust particles.

The P_{max} obtained before the dust deposition was (1.85W), Table 4 shows the P_{max} obtained from the Polycrystalline PV panel, after being coated with fixed amount of dust per sample each time. The table also provide the reduction percentage in power that resulted due the dust deposition each time; by utilizing the maximum power point for the panel as a reference point (1.85W).

Sample		Pmax	Pmax Reduction Percentages
1		1.476	20.22%
2		0.774	58.16%
3		0.651	64.81%

Table4:The Power Reduction Percentages due to each Sample

The obtained results show a significant decrease in the Pmax values after coated the panel with dust samples 2 and 3, where the dust grain distributions much comparable for the two samples. The minimum reduction percentages on P_{max} obtained from sample 1, which contained a larger percentage of coarse dust grains and less percentage of fine grains. Furthermore, the reductions percentages of third sample was a bit higher than second one. The percentage of medium grain size for the third sample was approximately 40%, while the percentage is greater for fine grain dust size (< 0.05mm) in the second sample.

Thus, it could be included that the ability of medium dust grain size in scattering and obscure the light, on the polycrystalline panel, were more than it for the fine dust grain size.

IV. CONCLUSION

The effect of dust grain size on the maximum output power point (PMAX) for a Polycrystalline PV panel were investigated in this work. The PMAX for the panel have been measured before and after being coated with three different samples of dust, which were collected from different locations in AHU.

The experiments result proved, that the reduction on the PV panel PMAX are proportional in the dust grain structure. It is also proved that the fine and medium particle size has more ability of spreading and covering uniformly over the PV panel surface, thus decreasing the amount of light transmitted to the panel and so reduce the maximum power point obtained from the panel. Based on this results, the geographical location for the first sample could be a recommended location to construct a PV station in AHU.

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