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Experimental Investigation of Dust Effect on PV Module Performance

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Abstract

The increasing of energy demand and present climate change are forcing the world energy consumers for looking towards the sustainable and environmentally friendly energy source, such as solar photovoltaic (PV). The performance PV system is primarily dictated by its surrounding environmental parameters, such as dust, temperature, solar radiation and humidity. The deposition of dust on PV module surface procreates less impact on an open circuit voltage whereas it procreates significant impacts on the short circuit current (ISC) and maximum power output (PMAX) of PV module. The present study persuades that the reduction of ISC and PMAX of PV module are 33.33

Index terms— dust, short circuit current, open circuit voltage, maximum power output.

1 I. Introduction

ater, power and health are three most essential things for any country. Apart from water and health, power is utmost important for every person. The production of power depends on fossil fuel, nuclear and renewable energy sources. Due to the fast depletion of fossil fuel and unsafe activity of nuclear energy sources renewable energy sources could be a good choice for power generation in future course of action **??**Sayigh., 2011). There are various types of renewable energy sources, such as biomass, geothermal, wind, hydro and solar. Among all renewable sources, solar energy experienced a rapid growth and popularity in last one decade (Mekhilef et al., 2011, Chueco-Fernández & Bayod-Rújula., 2010). In solar energy, solar radiation coming from sun is converted into electrical energy with the help of solar photovoltaic (PV) module. Photovoltaic is an effect in which, whenever sunlight strikes on PV module surface it creates free electron and hole pairs. This creation of free electron hole pairs is the main cause of electric power generation in PV system. The solar energy now a day's getting much more attention because of its availability and easy access in remote areas compared to other means of energy sources. Also the costs of PV panel have dropped substantially over the last few years (Dincer., 2011).

2 II. Effect of Dust on pv Module Performance

The performance of PV panel depends on various environmental parameters, like solar radiation, ambient temperature, humidity, wind speed and dust. Among these parameters dust affects the PV panel performance more significantly. Dust is defined as the minute solid particles less than 500 ?m in diameter. Dust deposition is a function of various environmental and weather conditions. Dust particles in the atmosphere generates from various sources, like movement of vehicles, drilling operation, working of HEMM, weather, volcanic eruptions, exhaust from industries etc. Such airborne dust particles settle down on PV module surface, which curtains the solar radiation falling on the module surface. (Saidan et al. 2016, Adinoyi & Said., 2013. The surface finish of the module, its tilt angle, humidity in the environment and wind speed influence the dust settlement on the module surface. Therefore, the deposition of dust on module surface varies from place to place. (Mani &Pillai., 2010 andKapsali., 2011). In a study it was found that due to sand dust deposition on PV panel surface the reduction in short circuit current (I SC) and maximum power output (P MAX) are respectively 40% and

34% (Hasan & Ghoneim., 2005). Similarly, another study shown that the reduction in PV module conversion efficiency were 10%, 16% and 20% respectively for 12.5 g/m 2 , 25 g/m 2 and 37.5 g/m 2 dust deposition on its surface (Shobokshy & Hussein., 1993). The study carried out for exposure of PV module for outdoor environment revealed that the reduction in glass transmittance was ranging from 90.7% to 87.6% after 33 days of its exposure into outside environment (Hee et al., 2012). One more study indicated that the dust significantly affects the optical transmittance of PV module, which reduces the electrical parameters like, Isc and Pmax up to 2.23% and 7.98%, respectively . In this paper an attempt has

3 III. Laboratory Set-up and Methodology

To understand the influence of dust deposition on module surface an indoor laboratory experiment was performed using 20W polycrystalline PV module at 545W/m 2 constant solar radiation. Red soil of size less than 75? was used in this study, which is prepared using sieve analysis process. The dust was distributed uniformly on module surface with the help of strainer. A set of solar simulators were used to generate an artificial solar radiation. A Digital Multimeter Fluke 178+ and DT830B were used to measure the electrical response of PV panel. The rheostat of rating 320 ohm was acting as an output load for PV module. Initially the electrical responses of PV module, such as current, voltage and power measurements of clean PV module were recorded by varying its load using rheostat.

To study the influence of dust accumulation on module, red soil was spread on the module surface, and its respective electrical responses were measured as discussed above. This procedure was repeated for three different mass deposition of dust, such as 5gm, 7gm and 12gm. Table 1 gives the variation in Isc, Voc and Pmax for four different conditions of module surface. With the help of these experimental results, current-Voltage and Power-Voltage characteristics of PV module are plotted.

4 IV. Results and Discussion

Figure **??** shows the comparison of I-V characteristics of PV module for different mass of dust deposition on the module surface. The results in Table 1 indicate that the reduction in I SC and V OC are respectively 33.33% and 6.64% for 12gm of dust deposition on module surface. As depicted in Figure **??** the open circuit voltage of PV module is less affected, whereas short circuit current is significantly reduced with increase in dust deposition. Due to this significant reduction in I SC the performance of PV module degrades considerably. Figure **??** depicts P-V characteristic of PV module for different mass of dust deposition. The reduction in P MAX is 42% for dust deposition of 12gm. The results of this study show that the reduction in I SC and P MAX of PV module depends on the mass deposition of dust particle on its surface. Moreover, the reduction in I SC and P MAX of PV module due to dust deposition is more significantly compared to V OC . This is because of the direct relation of solar radiation to the I SC , whereas the V OC of PV modules is proportion to the logarithm of solar radiation. The reduction shows a negative linear trend as shown in Figure **??** and Figure **??**.

The electrical responses of the module were also recorded for two type of above said dust pollutants and its current-voltage and power-voltage characteristic were plotted, which are shown in Figure **??** and Figure **??**. The reading of I SC , V OC and P MAX for all three defined condition (i.e., clean, covered by red soil dust and covered by lime stone dust) of PV module is given in Table 2. As given in Table 2 the influence of red soil dust on PV module performance is more severe than the lime stone dust. This indicates that the performance degradation of PV module is not only depends on mass of dust deposition but also on the type of dust. Further, to study the influence of type of dust pollutants on PV module performance two different types of dust pollutants, such as red soil dust and lime stone dust of size less than 75? were used. These dust pollutants were uniformly distributed on the module surface in the mass of 5gm and the electrical responses of PV module, such as current, voltage and power were recorded for both the type of dust.

been made to investigate and analyse the influence of dust deposition The performance of PV panel in a dusty environment can be decided by the term normalised power output. The normalised power output (P N) of PV module due to dust deposition is defined as the ratio of power output of dusty module (P d) to the power output of clean panel (Pc), as given in Equation **??**. Therefore, the reduction in normalised power output (P RN) of PV module can be defined by Equation **??**. The normalised power of PV panel in the dusty environment indicates the performance of a dust panel w.r.t a clean panel. The higher value of normalised power output represents the better operation of the module in dusty environment. The reduction in normalised power output measures the degradation level of module performance. The higher value of the reduction in normalised power output of PV module represents the higher level of the degradation in module performance. Therefore, it is very vital to know about the normalised power output due to dust accumulation on module surface. The relation of normalized power output and reduction in normalized power output of PV module with reference to the mass of deposited dust on its surface is shown in Figure **??** and Figure **??**. Solar energy could be a good choice of electrical power generation in remote areas, particularly in locations where access of power is difficult, like in mining areas, deserts, hill tops, forest etc. The aim of this paper is to study and analyse the influence of dust deposition on PV module performance. The results of the study shows that the reduction in short circuit current and open circuit voltage is respectively 33.33% and 6.64% for 12gm of dust deposition on module surface. The reduction in PV module performance due to dust accumulation is also depends on the type of dust pollutants. It

was found that the accumulation of red soil on the module surface affects the module performance more severely than the lime stone dust.

The reduction in maximum power output is up to 42%, which is significant when compared to power output of a clean PV module. This study demonstrated that the performance of PV module reduces with the increment in the dust deposition on its surface. Hence, this study demonstrates that a complete cleaning action of dust from PV module surface at regular interval must be ensured to improve the efficiency of PV module. [1]

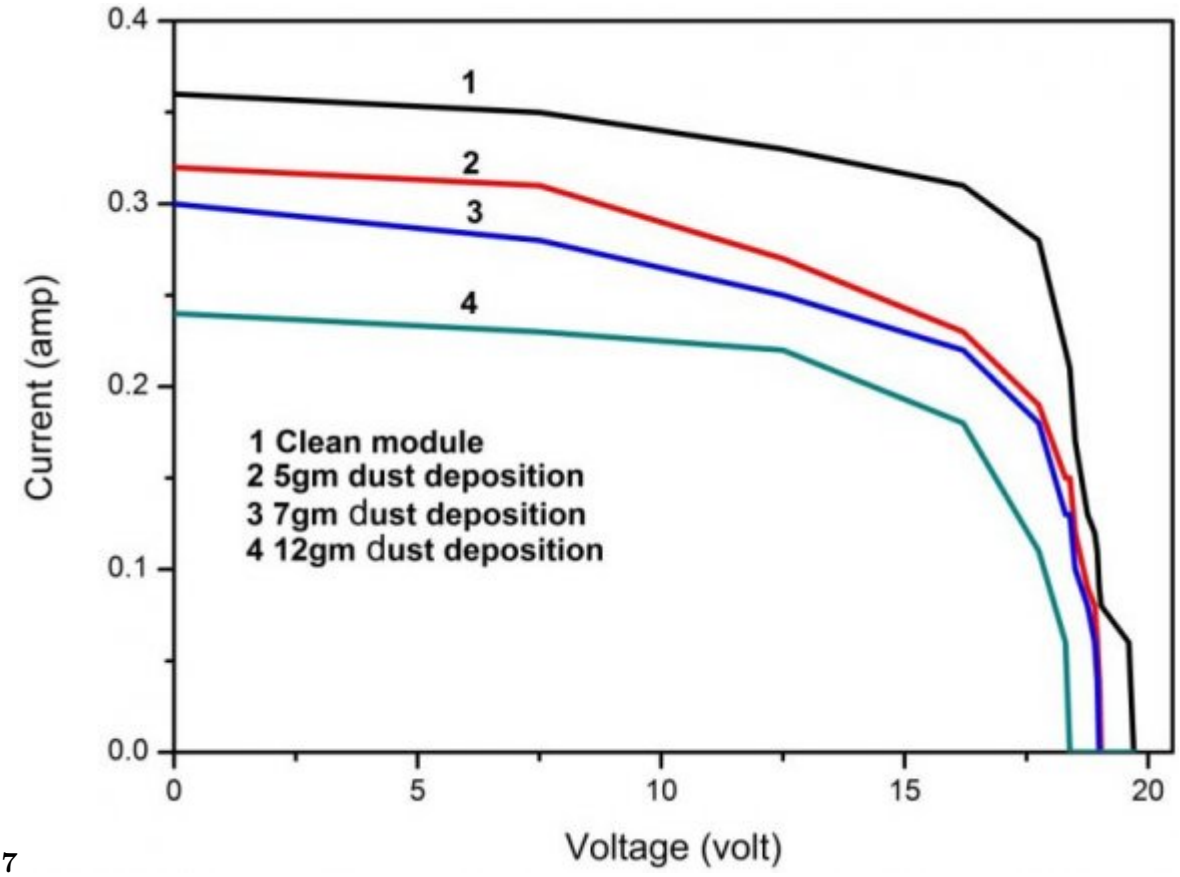

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Figure 1: W © 2017

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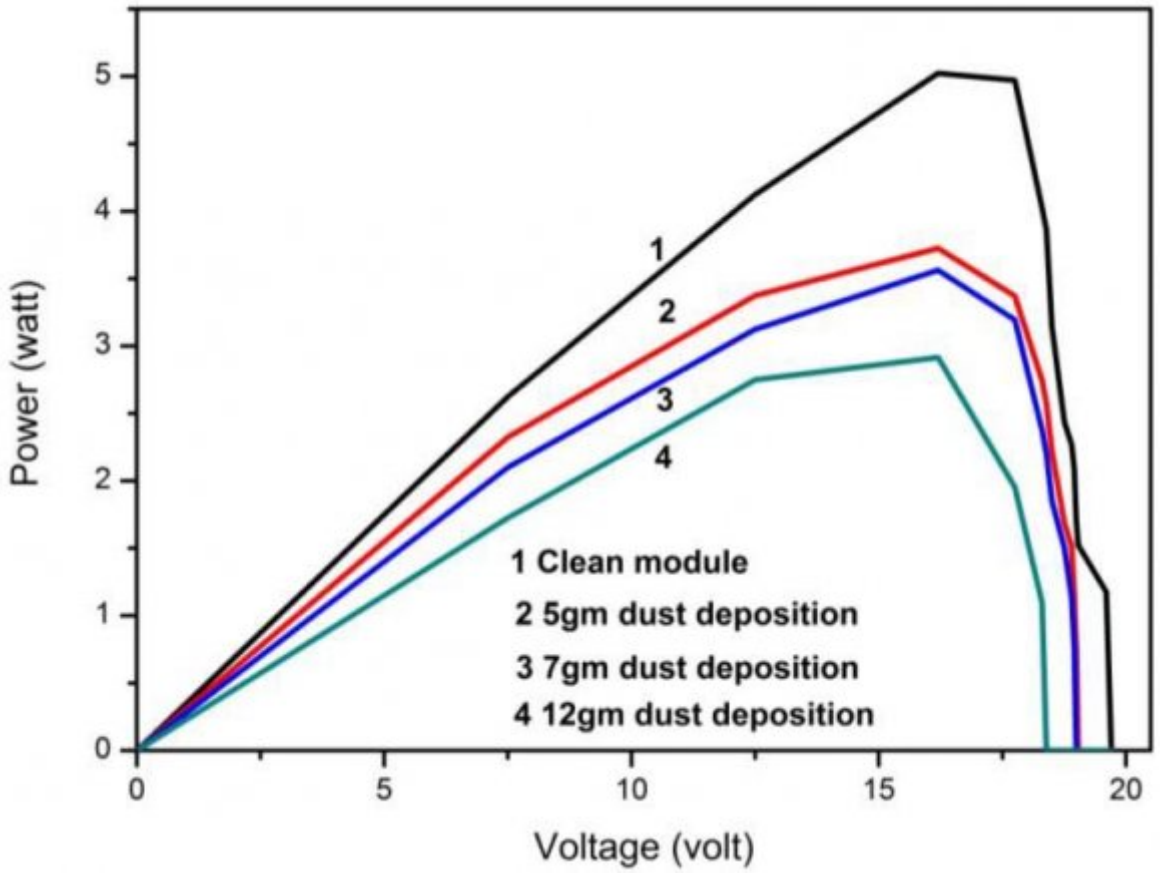

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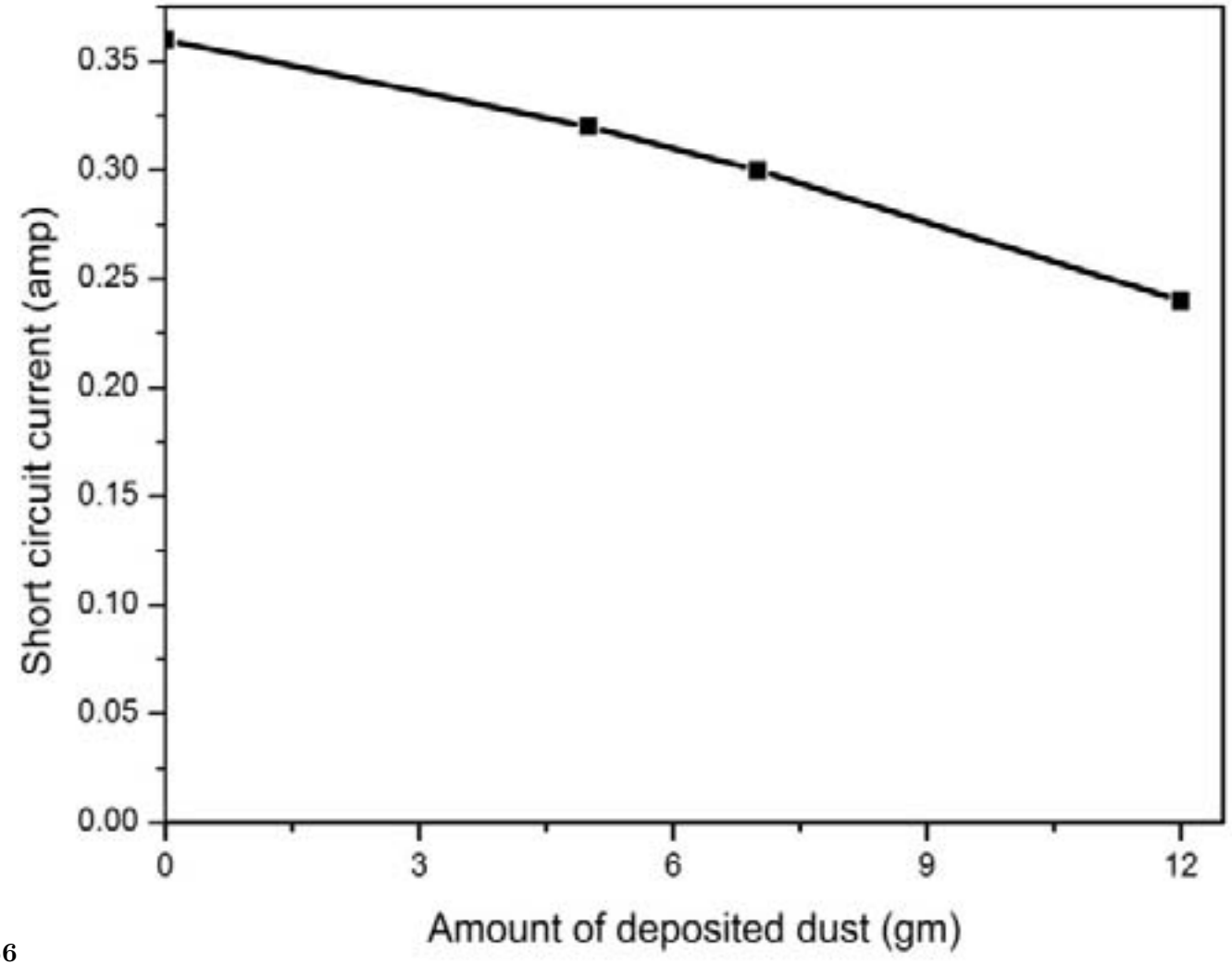

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Figure 3: Fig. 2 :Fig. 3 :Fig. 4 :Fig. 5 :Fig. 6 :

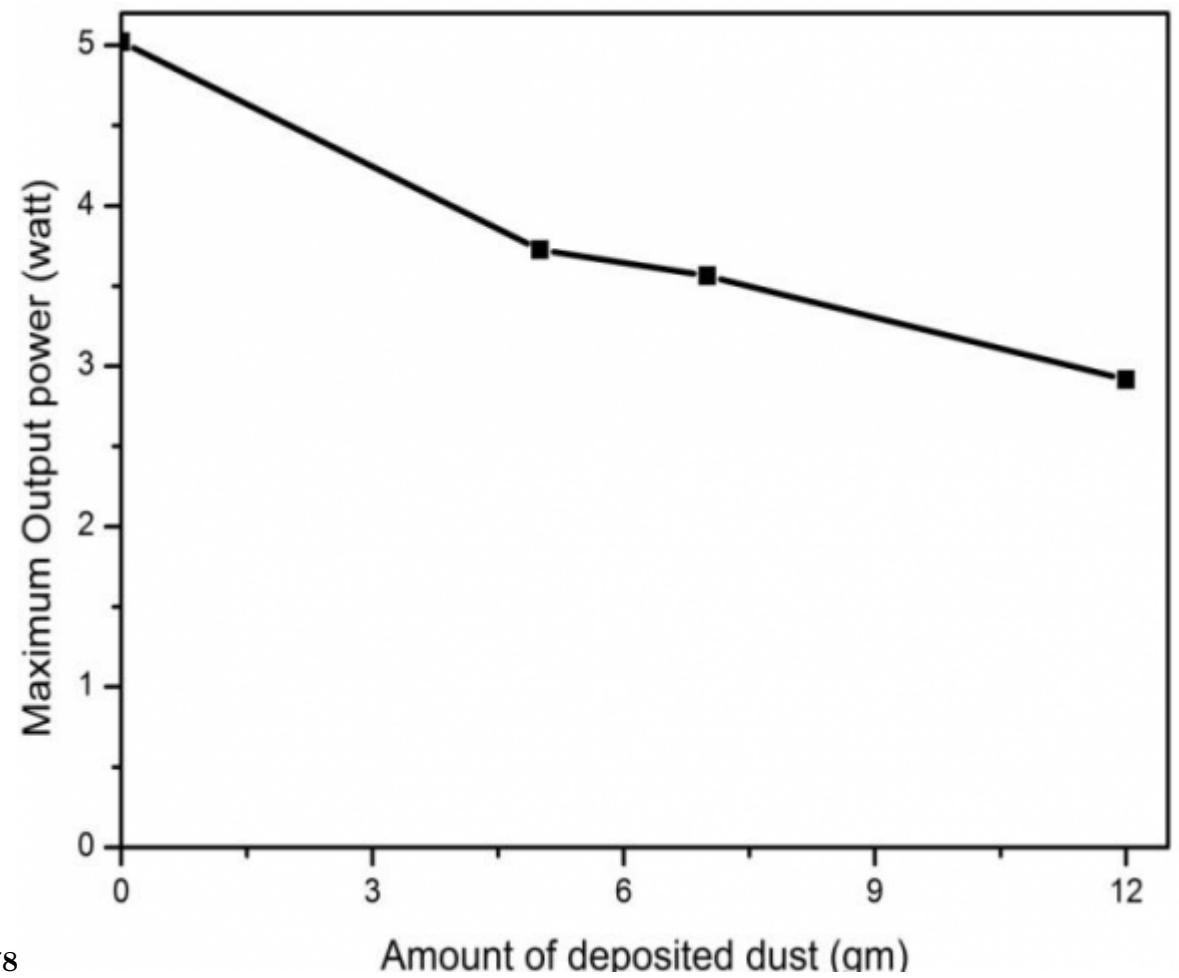

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Figure 4: Fig. 7 :Fig. 8 :

1

Dust (gm)	Isc (amp)	Voc (volt)	Pmax (watt)
0	0.36	19.70	5.022
5	0.32	18.95	3.726
7	0.30	18.90	3.564
12	0.24	18.30	2.916

Figure 5: Table 1 :

2

Module Surface Condition	I SC (amp)	V OC (volt)	P MAX (watt)
Clean condition	0.36	19.7	5.022
Dusty Condition (with 5gm of lime stone dust)	0.31	19.25	4.05
Dusty Condition (with 5gm of red soil dust)	0.28	18.95	3.726

Figure 6: Table 2 :

.1 Abbreviations

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