A Real Time Study to Detemine the Effect of Dust Deposition on the Power Output of PV Modules

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***Abstract*— Solar electricity is one of the promising renewable energy as it is direct, non-polluting and has demand of less percentage of land, water and abundant availability in nature. The performance of Photovoltaic module is mainly affected by high temperature and dust deposition. Studies show that the performance of panels over long period of time without rain events is highly reduced due to dust accumulation. Not only duration of exposure but also frequency and intensity of dust affects the pv panel's power output. Dust particles blocks the incident photons reaching the pv cell, thus reducing the useful area of the pv module. In this paper an indoor experimental test has been conducted and was found that dust accumulation greatly affects the short circuit current where as open circuit voltage has very little effect.**

***Keywords*— shortcircuit current, non polluting, Irradiance, capture loss**

I. INTRODUCTION

The revenue of PV power plant is related with electrical enrgy output of PV module. With the increase in panel output the pv industry can make it foot strong in the world energy market. Thus the various factors affecting the panel's performance has to be critically studied. Studies shows that the various factors which affect the power output of pv module are irradiance, temperature, angle of tilt, shading, soiling. Effect of dust accumulation becomes more predominant with long exposure of panels without regular cleaning. like N Ketjoy etal [1] studied the effect of dust accumulation on the the performance of pv panel using three different types of panel. He concluded that amorphous silicon panel with 260mg of dust accumulation shows 3.5% decrease in electrical output where as monocrystalline panel shows 2.96% decrease for same amount of dust deposition and polycrystalline panel shows 2.83% decrease. Jia yun hee studied the effect of dust on the transmission capacity of the glass. He found for 33 days of exposure of module samples at various tilt angles the transmission reduces from 90.7% to 87.6%. Studies shows that transmission effect is more from top portion of the slides rather then bottom portion.He suggested that glass slides coated with with TiO_2 causes easy removal of dust in comparison to that of without coating. During normal days dust particles accumulation varies from smaller size to bigger size but during dust storms bigger particles appear in larger amount. It is seen that due to decrease in photons generating photocurrent the current decreases remarkable.

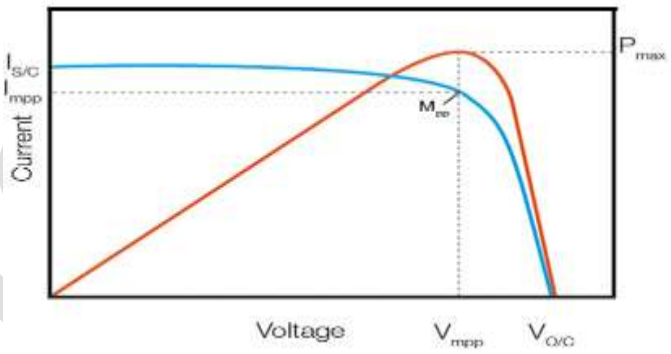

Fig. 1 Shows iv and pv curve showing maximum power point

II. METHODOLOGY

Dust analysis was carried out in laboratory setup using ECOSENSE solar pv analyser and two 37 kw module. The module specification is given as below. A solar meter was used to measure the irradiance level. Resistance temperature detector was used to measure the temperature of the pv module. Dust was spread evenly by using seaving process. Two number of halogen was used as artificial source of light. The output of dusty panel was compared with that of the clean panel and the readings are noted down in regular interval by changing the irradiance levels. The output characteristics of solar cells are expressed in the form of I-V curve.

Module Specification

Maximum power = 37W
Open circuit voltage = 21.8V
Short circuit current = 2.40A
Maximum voltage = 17.20V
Maximum current = 2.20A

Type: Vikram Solar:

Area = 0.367m^2, L = 66.5cm, b = 55.2cm
Quantity of Dust = 2.6g

Ecosense pv analyzer is a solar pv plant prototypes for training and research purpose. It consists of individual plug in units for

different experimental arrangements. There are also provisions for tilting the panels at various angles. The various components associated with it are power generation unit, artificial source of radiation, power conditioning unit, control and monitoring unit, and various accessories

Fig. 2 Shows solar pv analyzer used for the experiment

Fig. 3 Shows laboratory set up for clean panel and dusty panel

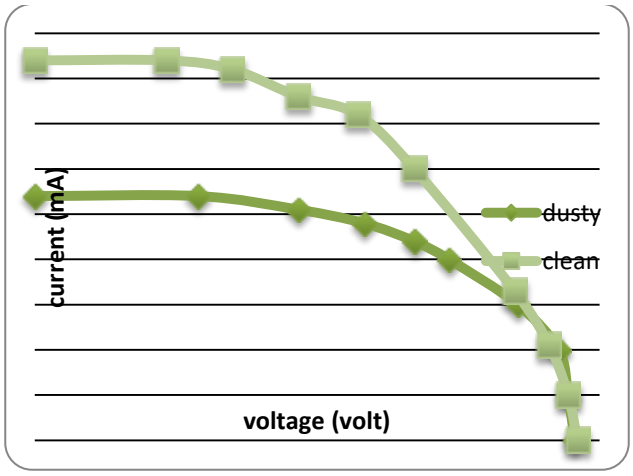

Fig. 4 Shows the iv curve for irradiance 220 watt/m^2

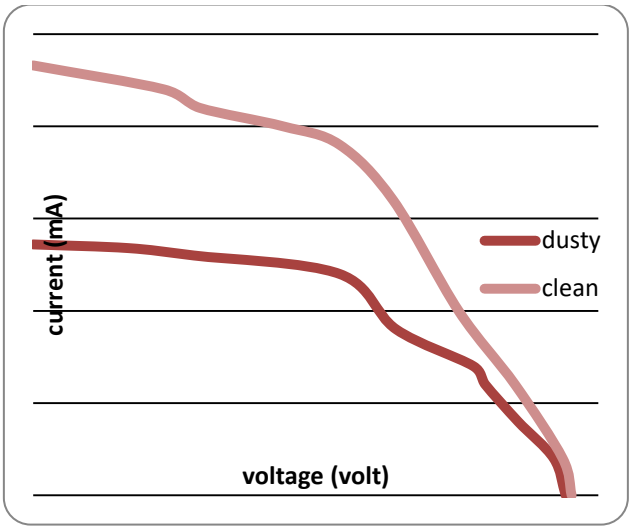

Fig. 5 Shows the iv curve for irradiance 470 watt/m^2

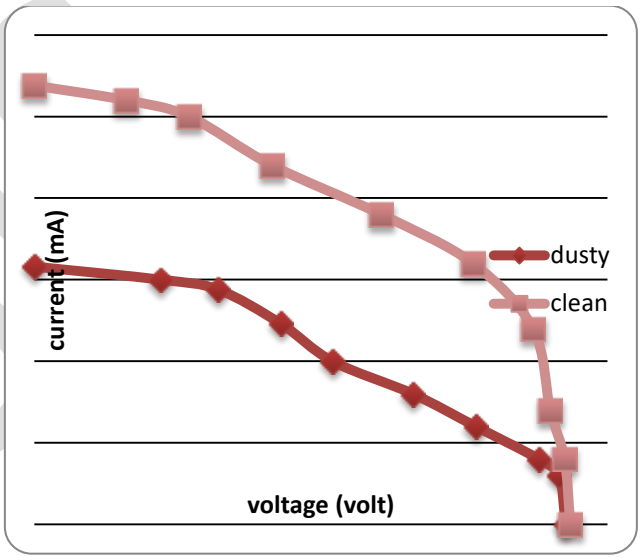

Fig. 6 Shows the iv curve for irradiance 640 watt/m^2

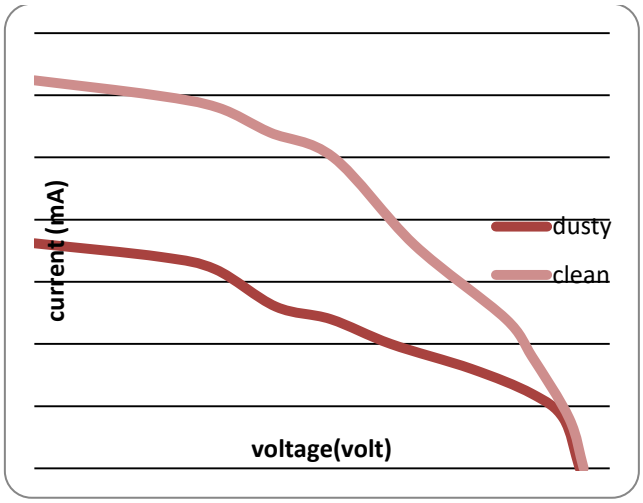

Fig. 7 Shows the iv curve for irradiance 764 watt/m^2

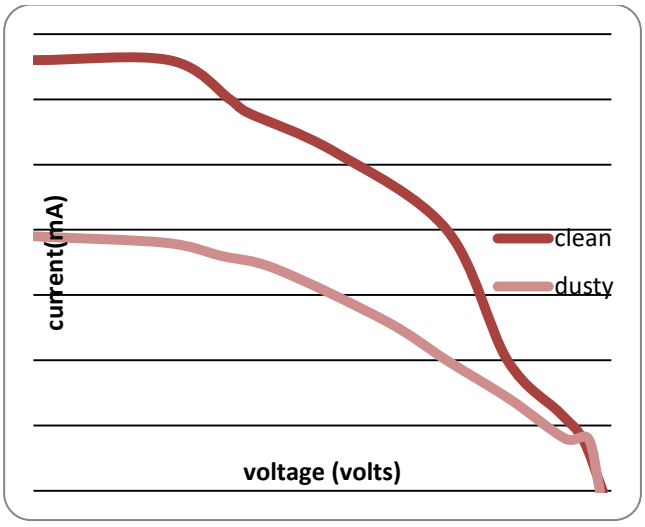

Fig. 8 Shows the iv curve for irradiance 880 watt/m^2

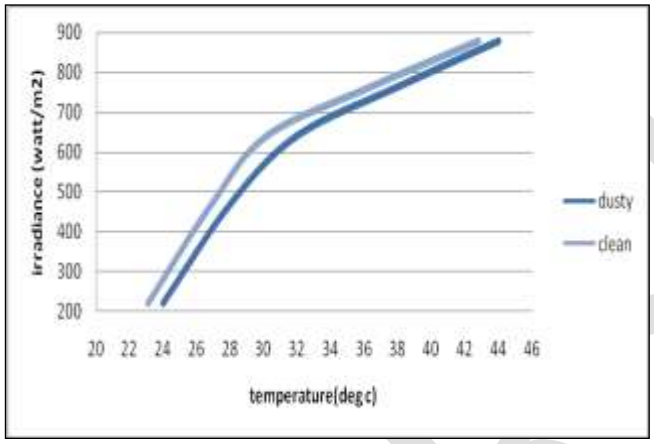

Fig. 9 Shows temperature of dusty panel more than that of clean panel.

TABLE I. SHOWS VALUES OF VOC AND ISC FOR CLEAN PANEL AND DUSTY PANEL WITH VARYING IRRADIANCE

Sl no	Intensity (watt/m^2)	Short circuit current(I_{SC})amp		Oper circuit voltage(Voc) volt		V_{OC} (%)	I_{SC} (%)
		Clean	Dusty	Clean	Dusty		
1	220	0.082	0.054	17.3	17.21	99.4	65.85
2	470	0.233	0.136	18.1	17.9	98.8	58.3
3	640	0.269	0.158	18.7	18.54	99.1	58.7
4	764	0.312	0.181	19.1	18.96	99.2	58.01
5	880	0.339	0.195	19.7	19.6	99.4	57

TABLE II. SHOWS TEMPERATURE OF CLEAN AND DUSTY PANEL

Sl no	Intensity (watt/m^2)	Temperature(deg cel)	
		clean	dusty
1	220	42.8	44
2	470	36.4	38
3	640	30.2	32
4	764	26.9	28
5	880	23.1	24

TABLE III. SHOWS THE AVERAGE POWER FOR BOTH CLEAN AND DUSTY PANEL

Sl no	Intensity (watt/m^2)	Average Power (watt)	
		clean	dusty
1	220	0.96	0.62
2	470	2.84	1.68
3	640	3.32	1.94
4	764	3.84	2.36
5	880	3.96	2.48

III. RESULTS AND DISCUSSIONS

1. Dust deposition does not largely affect the open circuit voltage of the PV module. At various irradiance levels open circuit voltage of dusty panel makes very small difference with that of the clear panel. The ratio of V_{oc} (dusty)/V_{oc} (clean) is around 99% for various intensity of light.
2. Accumulation of dust on the PV module greatly affects the short circuit current of the PV module. Considering various irradiance levels it is found that the difference in current o/p increases with increase in light intensity from 220 watt/m^2 to 880 watt/m^2. I_{sc} for dusty panels is less than that of clear panels. A difference of 40-50% I_{sc} drop is observed for dusty panels.
3. Dust density calculated is 5.722 g/m^2. Dust sample measured for indoor test is 2.1gm.Area = 0.367m^2.The power loss associated with the dust density is 40-50%.
4. Dust accumulation the PV module also affects module operating temperature. From the table it is clear that dusty panels have slightly higher temperature for same irradiance level i.e. 1-2^{o}c higher.

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