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Evaluation of Effect of Dust on Polycrystalline Silicon Solar Cell

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Abstract - ***Rising demand on existing power system results in power shortage, so solar PV system is proven best in atmospheric conditions of region like India. Efficiency and Fill factor of solar PV system are degraded due to dust and similar pollutants. The accumulation of dust on the surface of a photovoltaic module decreases the radiation reaching the solar cell and produces losses in the generated power. Dust not only reduces the radiation on the solar cell, but also changes the dependence on the angle of incidence of such radiation. This work presents losses caused by the accumulation of dust on the surface of photovoltaic modules and effect of dust layers on the transmissivity of PV module glass.***

Key Words: *Polycrystalline Silicon solar cell, Dust, I-V Characteristics of solar cell transmissivity of glass, Fill factor.*

1. INTRODUCTION

The sun is probably the most important source of renewable energy available today. Traditionally, the sun has provided energy for practically all living creatures on earth, through the process of photosynthesis, in which plants absorbs solar radiation and convert it into stored energy for growth and development. Scientists and engineers today seek to utilize solar radiation directly by converting it into useful heat or electricity. Two main types of solar energy systems are in use today: photovoltaic and thermal systems. There is a great deal of opportunity for using these systems in the world but the problem is that the deposition of dust on the solar panel. The deposited dust reduces the transmissivity glass which is responsible for low absorption of solar light by PV and hence reduces conversion ability of PV module.

2. OBJECTIVE

To evaluate effect of dust on polycrystalline silicon solar cell and the transmissivity of the glass covered on solar cell.

Effect of Dust accumulation on PV module

Generally solar power plants located on a very arid region that has frequent dust storms and dusty conditions. Deposits of dust on the surface of PV module blocks the solar irradiation from reaching cells through the glass cover. The density of deposited dust, its composition and particle distribution, can have an impact on the power output and current voltage and characteristics of PV modules. During the course of the study, it was observed that there is atmospheric dust that scatters the solar radiation, in addition to dust deposits on PV surface, which also blocks PV module from direct solar radiation. The study concluded that long period of PV module exposure to real outdoor conditions gradually decreases power output if no cleaning is performed to remove the dust.

What is Dust?

Dust is defined as the minute solid particles less than 500 μm in diameter. Minute pollens such as bacteria and fungi, and microfibers separated from clothes, carpets and fabrics are also known as dust when settled on surfaces. Dust deposition is a function of various environmental and weather conditions.

3. Experiment Methodology

In this study Lab level experiment was carried out with polycrystalline PV module connected with Control board (Ecosense) used for obtaining results.

The Specification of PV module is as:

Model: ELDORA 40, Manufacturer: Vikram Solar Pvt Ltd, Kolkata, India- 700001, Electrical Rating:

Rated Maximum Power (0 ~ + 4.99 Wp) (P_{mpp}) = 40 W, Open Circuit Voltage (V_{oc}) = 21.90V, Short Circuit Current (I_{sc}) = 2.45 A, Rated Voltage (V_{mpp}) = 17.40V, Rated Current (I_{mpp}) = 2.30A, Area of PV Module: 38.1 cm X 64.08 = 2441.48 cm^2 = 0.244 m^2. Power specification is measured at standard test condition, insolation 1000W/m^2, AM 1.5, 25^{o}C cell

temperature. Simulator (Ecosense) comprises Ammeter, Voltmeter, and Battery current.

In this research, indoor experiments are conducted to evaluate the effect of dust on PV performance. The PV module is tested using different dust elements. Since the dust effect is considered geographically site dependent, it is directly related to the local air pollution of the place where the PV system is installed. The investigation was conducted for different layers of dust separately. Single element of air pollution is selected to investigate effects on PV module performance based on experimental measurements. Red soil is obtained from playground.

In order to determine the impact of red soil dust on PV-panels performance, an experimental procedure is carried out in order to compare the voltage output of the PV module under different dust deposition conditions say, layer 1, layer 2, layer 3, layer 4, layer 5, layer 6. Layer wise dust deposition also collected on glass slides for the testing of transmissivity of glass. The experimental procedure was carried out indoors and at least 10 measurements were recorded within the time period examined. The experimental analysis is conducted in the Renewable Energy Laboratory located at the campus of the Department of Energy Technology, Department of Technology, Shivaji University, Kolhapur, Maharashtra India.

The dust deposition density "ΔM" is expressed in "g/m2", via the PV panel area "A", as ΔM = Δm/A (1) Where "Δm" is the total mass of dust layer on the surface of polluted PV panel.

Experimental Procedure:

Playground soil is collected, Screened that soil using 300 microns screen to form the dust size particle, Layer 1 was sprayed by hand and took the I – V readings, Plotted I-V characteristics graph, Power calculated using I-V readings, Same as (3, 4, and 5) Procedure was done for layer 2, layer 3, layer 4, layer 5 and layer 6.

Fig. 1 - Clean solar panel and dust deposited solar panel

Fig. 2 - Solar PV module Simulator

Effect of Dust on Transmissivity of Solar PV Module glass

For checking transmissivity of glass one simple experiment is done with the help of Department of Physics, Shivaji University, Kolhapur, Maharashtra, India. The Slides shown in figure is tested and the results of transmissivity with respect dust layers are tabulated. Transmissivity of glass slides with respect to layer. Here, Glass without dust was considered as a bare substrate or reference glass for finding transmissivity of glass with dust.

Experimental Apparatus

One LED Torch (DL 05 B 1U), Radiation meter with sensor and radiation indicator, Bare substrate glass and dust deposited glass slides viz. layer 1 to 6, Stand for fixing the sensor and Glass Slides.

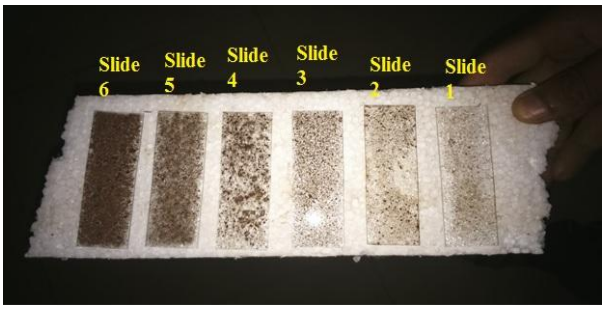


Fig. 3 – Glass slides layer 1-6.

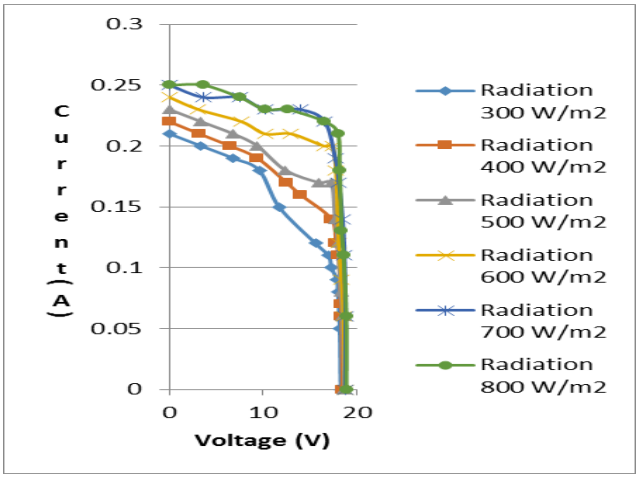
Experimental Procedure:

First, position of torch and sensor kept fixed at distance between sensor and flat surface 34 cm. Direct exposure of light is noted down and i.e. 211 W/m^2. After that incident light of torch is passed through the bare substrate (Glass without dust layer or reference glass) and exposure of light noted i.e. 203 W/m^2 which is considered as 100% transmittance. Step by step same procedure is carried out for glass slides layer 1 – 6 and transmittance is calculated as shown in graph.

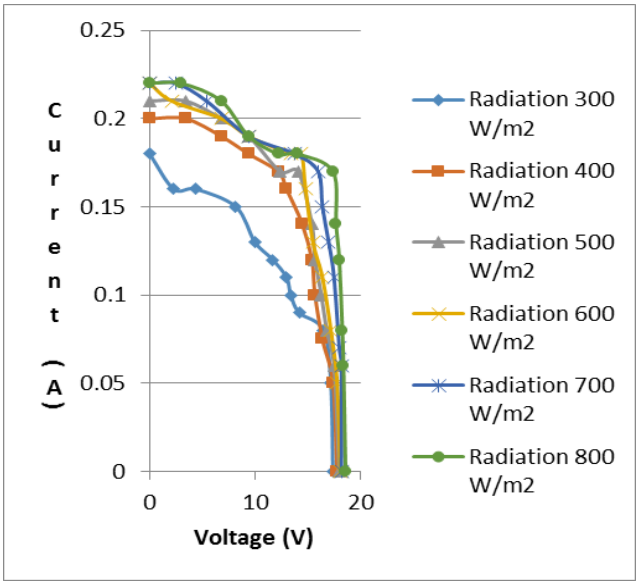
Fig. 4 – Transmissivity Check experimental setup

Results

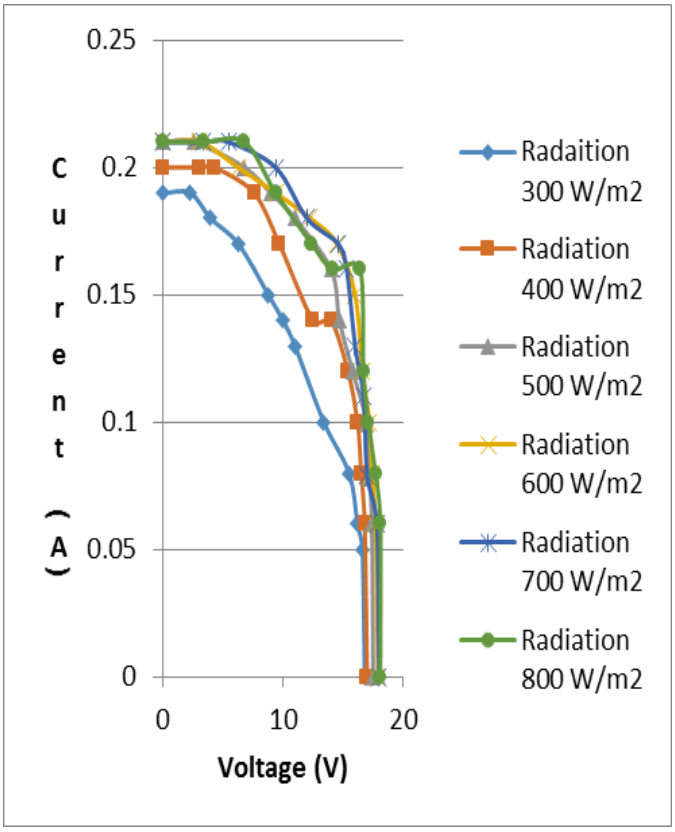
1. I-V Characteristics of Clean Solar Panel and Dust layer up to 6.



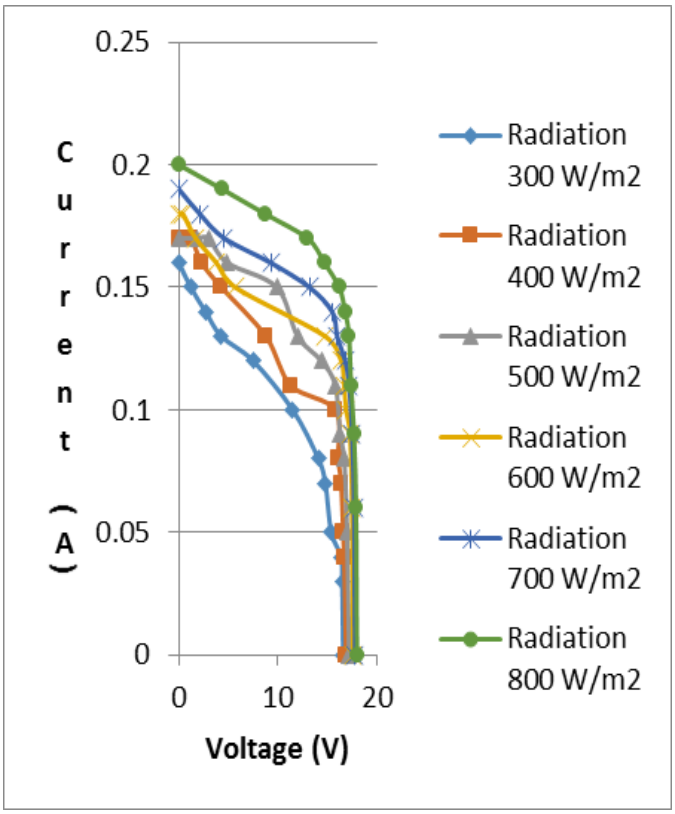
Graph 1- I-V Characteristics Clean solar panel



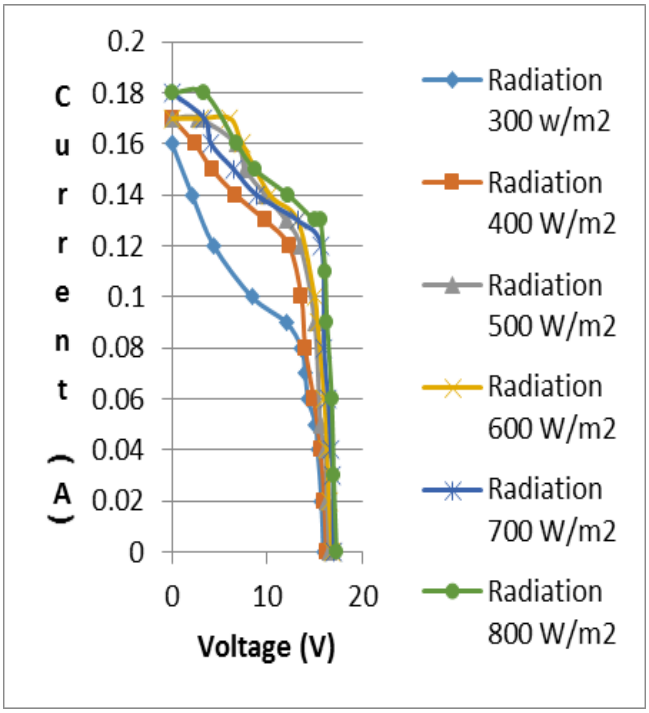
Graph 2 – I-V characteristics of Dust layer 1 on solar panel



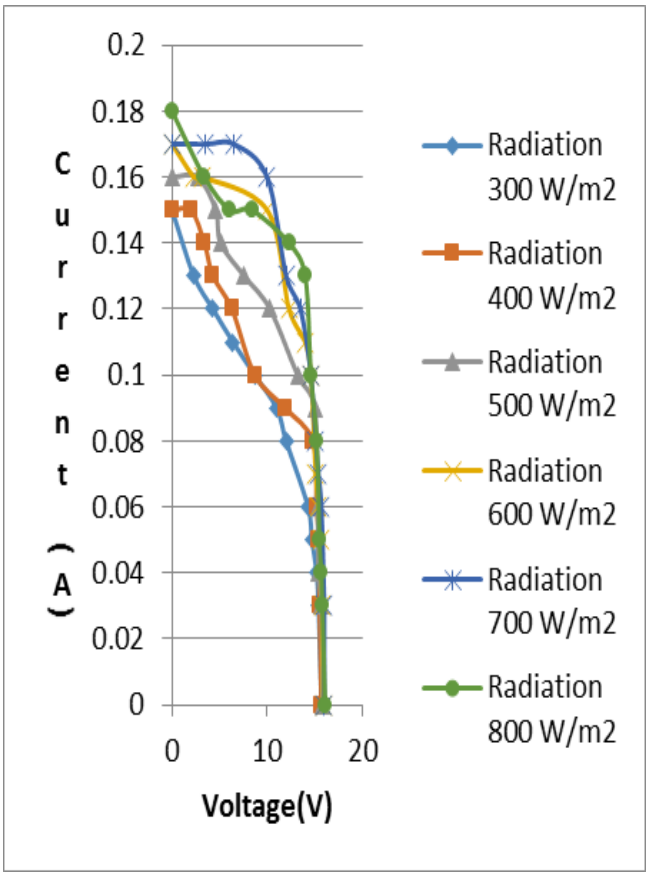
Graph 3 – I-V characteristics of Dust layer 2 on solar panel



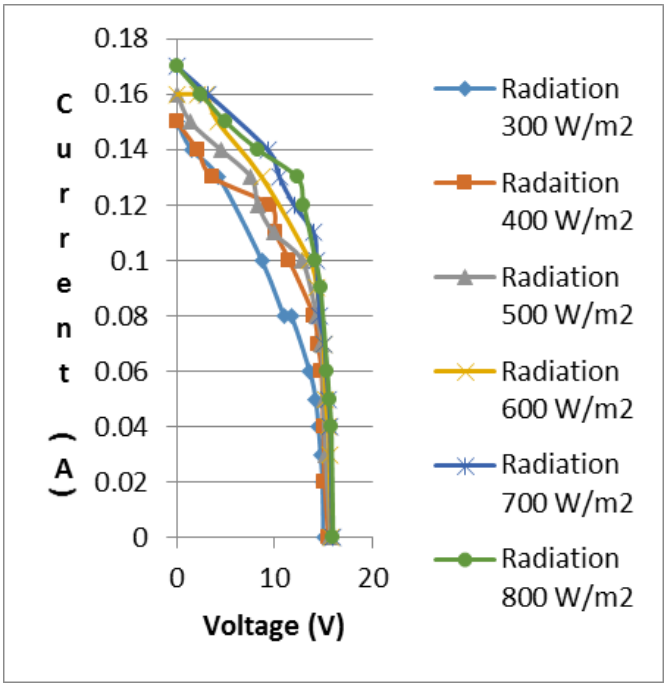
Graph 4 – I-V characteristics of Dust layer 3 on solar panel



Graph 5 – I-V characteristics of Dust layer 4 on solar panel

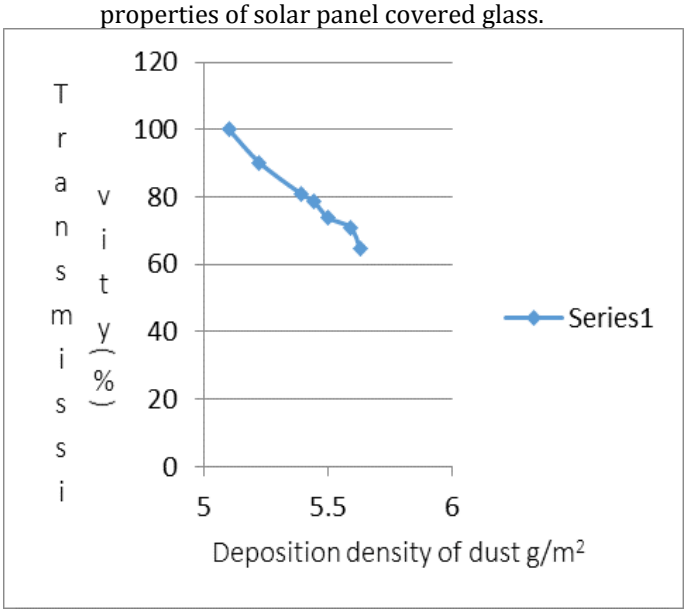


Graph 6 – I-V characteristics of Dust layer 5 on solar panel



Graph 7 – I-V characteristics of Dust layer 6 on solar panel

2. Transmissivity glass slides which have same properties of solar panel covered glass.



Graph 7 – Transmissivity v/s dust deposition density g/m2

Conclusion

Hence, Evaluation of effect of dust on Polycrystalline Silicon Solar Cell is carried out by doing experiment on indoor solar PV module and experimental data is tabulated in terms Graphs. Dust deposited on the surface of the Polycrystalline Silicon Solar cell reduces the transmissivity of the glass hence reduced power generation capacity of the Polycrystalline Silicon Solar cell.

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