Performance Analysis of Anti Soiling Module

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Abstract - Nowadays, soiling causes a significant energy loss in Photovoltaic (PV) modules. The moisture content over the PV Module Glass surface accelerates the soiling rate and It Makes adhesion stronger in between dust and glass surface. Several methods of cleaning the PV Module are laborious and expensive. Such problems in the field, Prompt towards the solution like; Anti-soiling coating on PV Module. This coating has a hydrophobic property which prevents sticking of dust particle over the glass surface. Outdoor field testing of the Anti-soiling (AS) PV Module has been conducted to validate the performance of Anti soiling coating. Performance of AS PV Module analyses by Measuring the I-V curve for the defined time period in outdoor conditions. The result shows that the AS PV Module gives 1.49 % more power than the Standard PV Module in outdoor test conditions. Soil Gravimetric density (SGD) Measurement of deposited soil over the PV Module is another way to access the quality of Anti soiling coating. The behaviour of different locations' soil varies, which was tested to identify optical losses in advance before PV installation. Each soil deposition condition AS PV Module performs better than Standard PV Module.

Keywords – Anti-Soiling coating, Dust accumulation, Performance Evaluation, Solar PV Module

I. INTRODUCTION

Solar Energy is one of the abundant Sources of Clean energy on Earth, especially in tropical countries like India (Latitude: 20.5937° N, Longitude: 78.9629° E). India receives an average of about 7000 MJ/m^2 of global solar radiation in a year over most parts of the country that is highly favourable to the use of the solar photovoltaic (PV) system and get a good amount of power generation.[1] However, in such areas, the soiling of PV Modules (as shown in Fig. 1) causes a significant performance loss. Soiling is a process where dust is accumulated on the glass of PV Modules and leads to a sunlight transmission loss. Here, the Main source of Dust is a Particulate Matter (PM), less than 500 µm in diameter. It originates from a variety of sources, such as wind, pollutants, airborne liquid constituents, particulates from construction. There is a wide dust variation around the globe in terms of colour and mineral composition. The composition of dust affects both the amount and type of soiling. The dust properties are also affected by ambient conditions, including humidity gradients, wind velocity and direction, and seasonal variation.[2]Also, there is observed up to 20% performance loss of PV Modules per month due to Soiling. So, It is a severe Problem recently.

Obviously, periodically cleaning of PV Modules is one way to decrease soiling loss. But this Cleaning process is very time consuming and expensive in many cases, especially water scarcity areas. Therefore, Anti-soiling Coating on the surface of PV Module will be an effective way to tackle the soiling problem. Anti-Soiling coating can be available in two types: Hydrophobic and hydrophilic. These coatings can reduce the adhesion of dust. The Experiment is conducted using Hydrophobic Anti-soiling Coating because of its very good water repellent property which leads to reduce the soiling loss and saves water due to which Cleaning cycle of PV Module decrease too.

Fig. 1 Soiled PV Module

The objective of this study is Identify the performance of AS PV Module as compared to Standard PV Module.

II. EXPERIMETAL SETUP

The experimental setup is located on the roof of Waaree Energies Limited, SEZ Surat. Due to Industrial location many activities like manufacturing, Vehicle Pollution,Dimond cutting works, construction etc. that can generate dust and Pollutants. The setup is located on rooftop approximately 15 meters above the ground. Two Polycrystalline PV Modules of 330 W AS PV Module and other Standard PV Module have been kept at a tilt angle of 23 degrees and oriented at true south direction [2] as shown in Fig. 2.

Various ways can be used for evaluating the performance and validation of the AS PV Module.

Fig.2Anti-soiling (AS) PV Module (Left) and Standard PV Module (Right)

Firstly, both PV Modules were kept in outdoor soiling condition for one Month and measures I-V Curve in different time slots by using PV Analyzer every day. The Experiment was conducted during December 2019 - January 2020. At the end of the test, the performance of AS PV Module evaluated.

Moreover, different locations[3] depending on the soil deposition pattern and types, with their effect on the performance of the AS PV module and that of the standard one were selected, such as soils at Pune, coastal regions like Bhavnagar, and plateau as seen in the city of Hyderabad. The study was made in certain periodicity of data. In this method, the Effectiveness of Anti soiling coating analyses by Comparing Standardized weight differences of soil content over the AS PV Module and Standard PV Module. Additionally, this method helps to predict the effectiveness of Anti soiling coating as per different locations. This Test includes several Important stages Like; Preparation, Deposition, Dry Cotton Method (DCM) Application and Soil Gravimetric Density (SGD) measurement.

In the **Preparation stage**, PV Modules have been cleaned one hour before the test. Preparation of Two soil samples of 100 gm each and two dry cotton samples of the same weight Requires before the deposition stage.

During the **deposition stage**, different locations' soil samples (as shown in Fig. 3) are deposited using a strainer over both PV Modules one after another. After deposition, PV Modules kept as it is for five days. Initially, the soil deposited over the PV Module's topside on the day of deposition but after five days quite uniform soil distribution was found over the PV Module during the visual observation. The amount of soil that is stuck over the PV Modules during this time period characterizes the performance of Anti Soiling Coating.

After Visual observation, the amount of soil stuck over the PV Module need to be measured in the **DCM stage**. During this stage, dry cotton helps to clean the PV Module for measurement purposes. Weighted dry cotton samples damped in water and use it to clean the AS PV Module and Standard PV Module separately one after another. The soil over the PV Module is adhered with wet cotton during cleaning and remains with the cotton samples. These samples put in the oven for drying

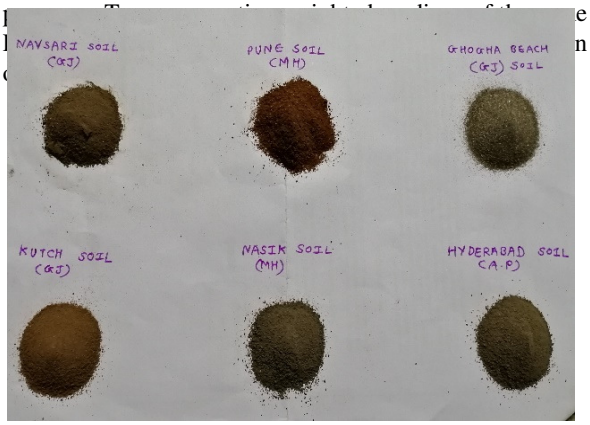


Fig. 3 Different Locations' soils

In **SGD Measurement stage**, the Calculation of soil gravimetric density is done by using the weight of cotton Samples before and after the test and Standardize it with respect to the area of PV Module.

$$SGD = \frac{M_{after} - M_{before}}{A_{Module}} \quad (1)$$

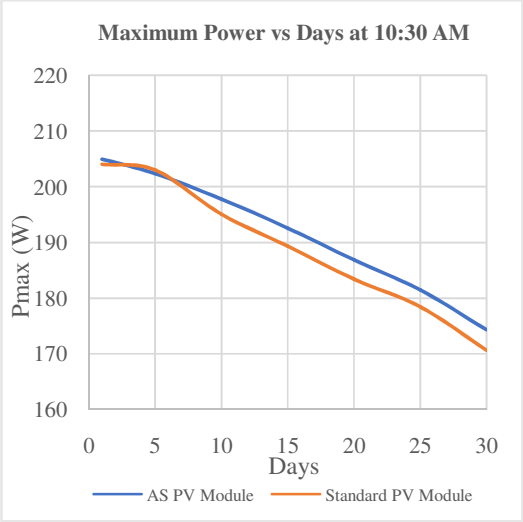
where,
SGD = Soil Gravimetric Density (g/m^2)
M_{after}= Mass of dry Cotton after the test (g)
M_{before}= Mass of Dry cotton before the test(g)
A_{Module}= Area of PV PV Module (m^2)

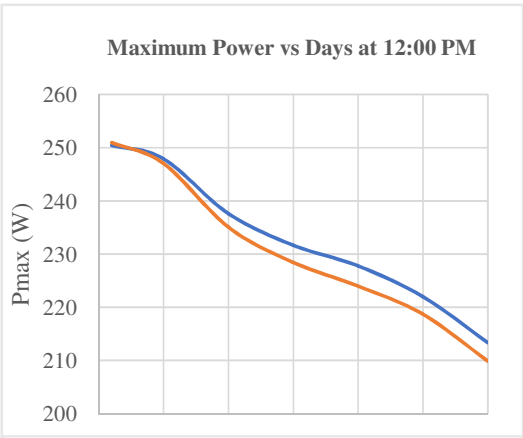
III. RESULTS AND DISCUSSIONS

Solar irradiation, which may get affected by the aerosol containing the dust, and thus affecting the transmission of the radiation. By loss of solar radiation on solar cells, the short circuit current of the PV Module is lower down and hence, getting less output power from PV Module.

To estimate the performance of the AS PV Module, we need to compare with Standard PV Module and for that, we prepare a different graph like Maximum power vs days, short circuit current vs days.[4]

As shown in the Fig. 4, we were taking readings the whole day with different time slots like 10:30 AM,12:00 PM, and 02:00 PM. Initially, the output power of Both Anti-Soiling (AS) PV Module and Standard PV Module were almost same due to the low soiling effect. As days pass away, the soiling effect was started and at the end of the 30^{th} day, the average power degradation due to Soiling for Standard PV Module was around 16.37 % and for AS PV Module was around 14.88 %. The average power difference between both AS and standard PV Module was around 1.49 %. so, it may be emphasized that AS PV Module was giving 1.49 % more power than Standard PV Module.





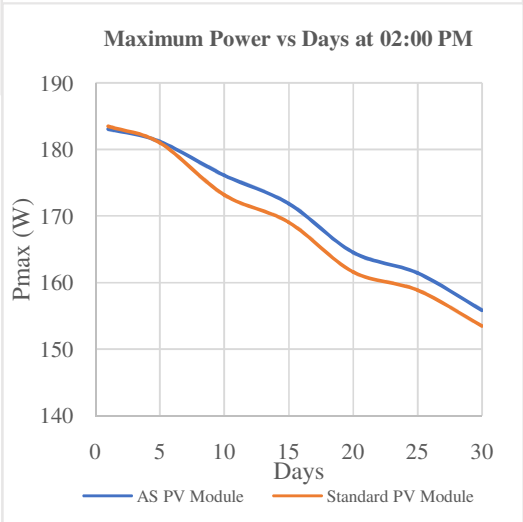
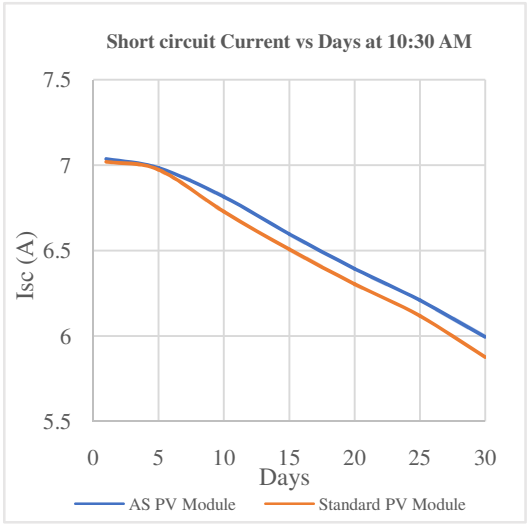
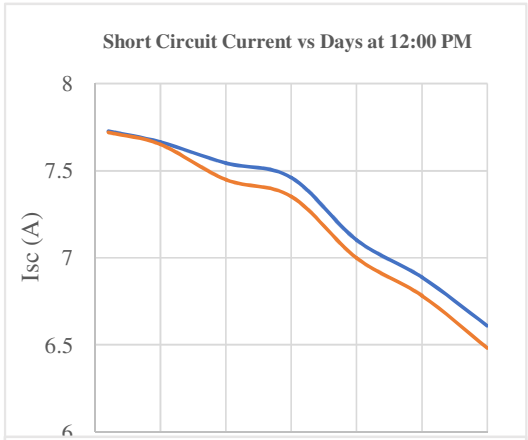


Fig. 4 maximum Power measurement of AS and Standard PV Module on different time in a day for 30 days





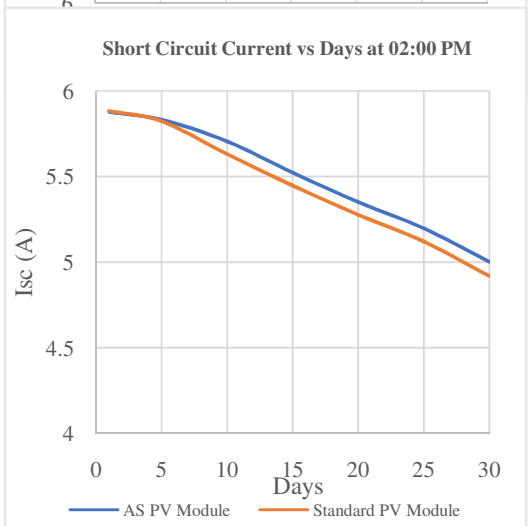


Fig. 5 short Circuit Current measurement of AS and Standard PV Module on different time in a day for 30 days

As we know, soiling can affect the transmission so cause in reduction of short circuit current too. Behaviour of Both PV Modules have reported for effect of soiling over short circuit current also which shown by using graphs in Fig. 5. During initial days the short circuit current was almost the same for both AS and Standard PV Module and at the end of the 30th day, the average short circuit current degradation due to soiling for Standard PV Module was around 16.38 % and for AS PV Module was around 14.92 %. The average short circuit current difference between both AS and Standard PV Module was around 1.51 %.

To estimate the efficacious of anti soiling coating on PV Module, we were measured stickiness of different locations' soil on PV Modules by using Dry Cotton Method (DCM). This method helps to predict amount of Optical loss due to Sticking behaviour of soils. Results of this method are shown in the Fig. 6. SGD of AS PV Module is lower compared to Standard PV Module in Each Locations' soil. Behaviour of Nashik soil exhibits more stickier as compared to other soils although less effect on AS PV Module as compared to standard PV Module where Bhavnagar seaside soil effect is lower for both PV modules.

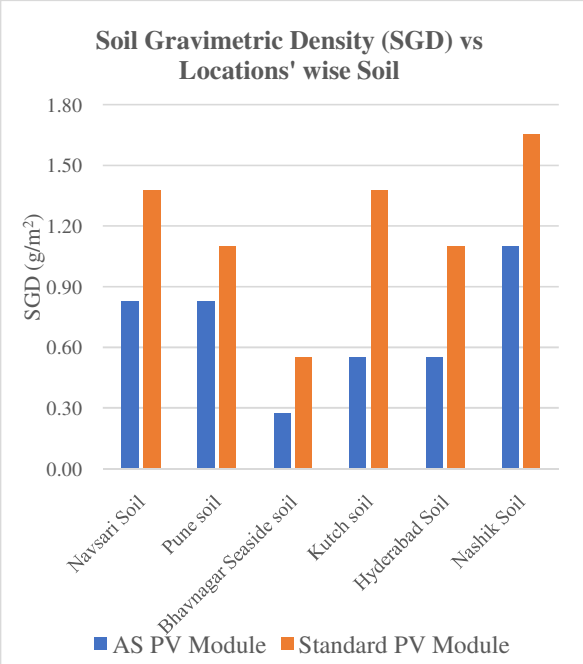


Fig. 6 Soil Gravimetric Density (SGD) of AS and Standard PV Module for Different Locations' soil

IV. CONCLUSION

Most of the earlier studies on soiling over solar PV module were done by taking small laminated solar cell structure that were naturally or artificially soiled. Experiment have been conducted under natural soiling condition for one-month period, which results shows the performance of anti soiling coated module was promising due to power gain of 1.49 % compared to standard module. For large scale application power gain due to anti soiling coating over Modules will exceedingly beneficial for Solar power plants.

In the method of quantify the quality of anti-soiling coating over PV module was measurement of SGD by artificial deposition of different locations' soil. Experimental results show that Nashik soil has critical impact over both module due to fine and moisturise particle nature even though performance of anti soiling coated module founds better compared to Standard without coated module. The Bhavnagar seaside soil has lower impact over both modules due to coarse nature of soilparticle.

In future the value of SGD helps to predict the severity of particular location soil as well as Effectiveness of Anti soiling coating over a module at particular location.

V. REFERENCES

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