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Characteristic Parameter Variation Study on Solar Photovoltaic Panel Using Hydrophobic Material Coating

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Abstract:

Due to pollution everywhere in outer location too much dust collected on glazed surface of photovoltaic panel which reduce the radiation penetration and life of photovoltaic panel. Hydrophobic materials have self-cleaning characteristic so it reduces cleaning cost and any external efforts of cleaning and enhance the efficiency of photovoltaic module. This research study aims to find out how hydrophobic material improves the overall cost of maintenance of photovoltaic panel. In this experimental investigation experiment performed on two photovoltaic panels i.e. coated and reference and find out comparison difference on the basis of electrical parameters i.e. voltage, current, power etc. It found that efficiency drops 0.46% maximum comparison to reference panel which was uncoated. But it reduces the cleaning cost of panel, those panels which required cleaning in 15 to 30 days now this time once in a month.

Keywords **—**Solar Photovoltaic Panel, Hydrophobic Layer.

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I. INTRODUCTION

In present scenario energy demand is increasing with development of nation, we have to rely more and more of renewable energy sources. Solar energy is mainly source which is available everywhere. To gain more powers from it have to focus on its structure and efficiency parameters but due to dust deposition the efficiency and life of photovoltaic panel reduces. So we have to adopt some new techniques to enhance life time and efficiency of photovoltaic panel. In nature there is a self-cleaning many examples i.e. butterfly and lotus leaves whenever a dew drop or water drops lie on it automatically drop fall out, this is called self-cleaning concept. And hydrophobic material's characteristic based on these concepts. Whenever dust accumulation on it that cannot adhere on it.

The self-cleaning concept is related to the surface contact angle. It is the angle formed at the three phase boundary(solid/liquid/vapour) between the surfaces of the liquid drop to thesurface of the solid. In general, if the contact angle is <90° thesolid surface is termed as a hydrophilic surface. When the contact angle(CA)is>90°,thesur face is defined as a hydrophobic surface [4].The hydrophobic or water repellent surface with a high water contact angle of greater than 150^{o} and self-cleaning property exists naturally in certain plant leaves like lot us leaves, rice leaves and wings of butterflies has gained interest so fresearchers to artificially fabricate it, and apply it to the window glasses, solar panel, energy conversion and conservation, air space ship and navigation of ships, to prevent marine fouling. Thisnatural idea can be applied on synthetic surfaces toovercomesolarpanelbasedproblems [1].

The self-cleaning technology was developed by Boston University professor Malay K. Mazumder and his colleagues, in association with the National Aeronautics and Space Association, and was originally intended for use in rovers and other machines sent to space missions to the moon and to Mars. The technology involves the deposition of a transparent, electrically sensitive material on glass or on a transparent plastic sheet that cover the panels. Sensors monitor dust levels on the surface of the panel and energize the material when dust concentration reaches a critical level [2]. The desert environments where many of these installations reside often challenge the panels with dust storms and little rain. Currently, only about 4 percent of the world's deserts are used in solar power harvesting. Conventional methods of cleaning solar panels usually involve large amounts of water which is costly and scarce in such dryareas [2].

The manual cleaning process is time-consuming, costly, and hazardous and might result in corrosion of the panel frame.On the other hand, using the self-cleaning hydrophobic SiO_2 nano material coating increases the output power by 15% compared to the dustypanelandby5%morethantheuncoatedmanuallycleanedpanel [6]. The tilt angle affects the amount of energy collected by photovoltaic module [5].

The desert area is abundance source of solar energy and in Rajasthan state abundant desert area also needs these kinds of self-cleaning techniques for photovoltaic collectors;. But there are also highly chances of damage of glazed surface due to dust deposition so have to move on self-cleaning technology like hydrophobic material coating. There are many hydrophobic materials SiO_2, Si_3N_4, TiO_2 etc. In this research study we use SiO_2 hydrophobic coating. The object of this research study is bestowing impact of nano metric hydrophobic coating on the electrical parameter of the photovoltaic panel [6].

II. EXPERIMENTATION

The study has an investigation characteristic with mainly the effects of hydrophobic nanomaterial solution film on glazed surface of photovoltaic panel. For research study developed a simple experiment on photovoltaic panels. The experiment was conducted at the CAZRI, Jodhpur at the geographical situation 26.249 latitude and 72.996 longitudes. In this study we use two photovoltaic collectors mounted on the ground of the renewable energy department (CAZRI, Jodhpur) facing south at a tilt angle of 36°. The first photovoltaic module considered as reference panel and the second one testing panel which was coated with SiO_2 hydrophobic solution film.ThesolarphotovoltaiccollectorsareofEIL 40type,manufacturedby Exide Industries Ltd.Table 1, presentedthemaintechnical characteristics ofthecollectors.

Table 1

Parameter	Value
Maximumpower	40 W ±5%
Maximumcurrent	2.40 A
Maximumvoltage	22.18 V
Normaloperatingtemperature(NOCT)	25°C±2°C
Cellstechnology	MonocrystalSi
Mass	4 kg
Dimensions	430×665×34mm

Comparison performance of the two photovoltaic panels was found on the basis of electrical parameters. It was designedand manufactured an original data observation panel from which measure the following parameters,intensityofthe current(I) and voltage (V), Global solarradiationinthecollector'splane(G). Thesensors types used for data acquisition asPyranometer:Davis6450 and digital current and voltage meter. Thepyranometeris mountedontheadjustableplatformandhasaconversionfactorof 157mVper1kW/m^{2}ofsolarirradiation. A dataloggerregistersmVreadingsreceivedbythePyranometerandthermocouplesandconvertsthemtoirradiationin(W/m^2)and temperature in°C.

III. METHOD

In this experimental investigation two panels are used one as reference panel another one as testing panel which is coated, for coating spray coating technique which made thin nanometric film of hydrophobic material.

Figure 1. Diagram of solar photovoltaic reference and testing Panel

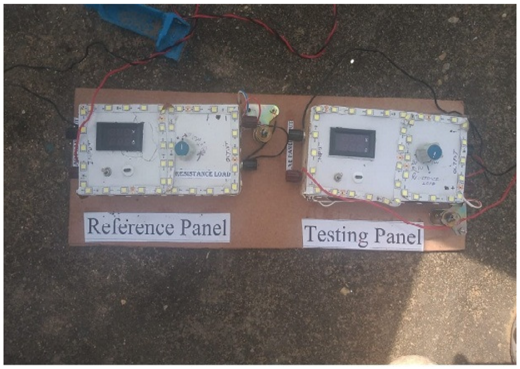

Figure 2. Observation setup

The effect of the hydrophobic layer of the performances of the solar photovoltaiccollectorswasevaluatedbycomparisonbetweenthe valuesofelectricalparametersofperformances. Some of these parameters were measured, such as intensity of the current (I)and voltage (V). The values of the other parameters of performance, such as power (P) and efficiency (η) were calculated based on their fundamental relationsofdefinitionindicated asfollows.

Theelectricpower(P),wascalculated with equation (1)

$P=I\cdot V[W]$ (1)

Where

I [A]is theintensity ofthe currentand

V[Volt]is thevoltage.

Theefficiency (η),wascalculatedwithequation(2)

$$\eta=P/(G\cdot S)[W] \quad (2)$$

Where P [W] is the electric power,

G [W/m^2] is the global solar radiation and

S=0.646m^{2}is the area of the glazedsurface ofthe collectors

IV. RESULT ANALYSIS

The results concerning cumulated energy production are covering the one week period of the study, in the five hours (10:30 AM to 3:30 PM) 0f maximum solar radiation (700 – 1056) W/m^2. The time interval for the recorded data considered in analysis was of 10 minutes. Total 31 observations counted. The presented results were obtained both from direct measurements and calculation, following the described methodology. During whole day the peak time solar radiation was 1056 W/m^2 and nadir time solar radiation was 195 W/m^2. The hydrophobic solution determined a current drop of (1.78 – 3.35) % representing performance shift down as in figure 3. The hydrophobic solution determined a voltage drop around 2.50% representing performance shift down.

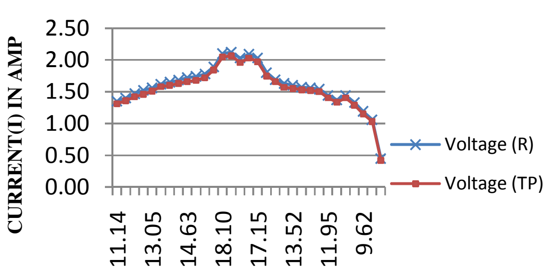

Figure 3. Variation of Current and Voltage

The hydrophobic solution determined a power drop of (4.40 – 5.50) % determined by the current decreases and representing a performance shift down. The hydrophobic solution determined a cumulated power drop of 5.50% representing performance shift down.

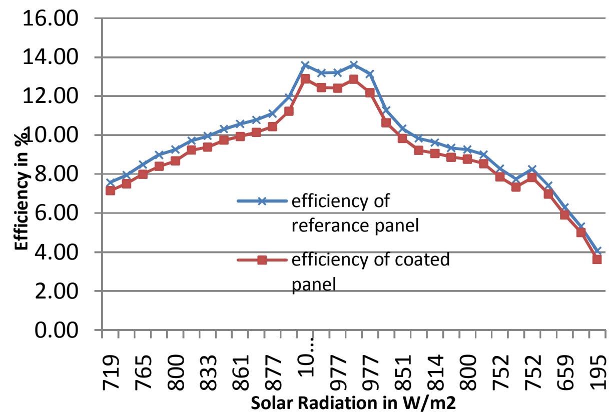

Figure 4. Efficiency of Reference Panel and coated testing

The hydrophobic solution determined an efficiency drop of (0.31 – 0.46) % determined by the power decrease and representing a performance shift down in figure 4. The hydrophobic solution determined a cumulated power drop of 6.16% representing performance shift down.

The hydrophobic solution determined a cumulated efficiency drop of 0.46% representing performance shift down.

V. CONCLUSIONS

The current drop with (1.78 – 3.35) % is representing an important shift down ofelectric performance. The voltage increase is negligible with (0.0 - 1.7) %, suggesting that thehydrophobic layer does not affect the voltage. The power drop with (4.40 – 5.50) % is mainlydue to the current drop. The efficiency drop of (0.31 – 0.46) % in absolute values is alsorepresenting a significant deterioration of collectors performance capability. Based on this experimental analysis, the use of SiO_2 hydrophobic nanomaterial coating reduces the efficiency slightly but that will increase the overall efficiency of the solar PV panels. This is due to the ability of the coated panel to remove dust with no effects or any external act.

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