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Comparative Study on Solar Photovoltaic Panel Using Hydrophobic Material Layer

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ABSTRACT:*Location of solar panels are open to sky and too much dust collected on glazed surface of photovoltaic panel due to different reasons which reduce the radiation penetration and life of photovoltaic panel. Efficiency of solar panels decreses due to dust accumulation thus required frequent cleaning with abudent quantity of water and in desert area where scarcity of water we need self cleaning procedure. As 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 0.65% comparison to reference panel which was uncoated. But it reduces the cleaning cost of panel, those panels which required cleaning in 15 days now this time reduce now once in a month it needs cleaning.*

KEY WARDS: *Solar panel, hydrophobic material*

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I. INTRODUCTION

In present scenario energy demand is increasing, 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 phenomenon is related to the surface contactangle.Itistheangleformed atthethreephaseboundary(solid/liquid/vapour) between the surfaces of the liquid drop to thesurface of the solid. In general, if the contact angle is $<90^{\circ}$ thesolid surface is termed as a hydrophilic surface. When the contactangle(CA)is$>90^{\circ}$,thesurfaceisdefinedasahydrophobicsurface [4].Thehydrophobicorwaterrepellentsurfacewithahighwatercontact angle of greater than 150^{o} and self-cleaningpropertyexistsnaturallyincertainplantleaveslikelotusleaves, rice leaves and wings of butterflies hasgainedinterestsofresearcherstoartificiallyfabricateit,and apply it to the window glasses, solar panel, energyconversionandconservation,airspaceshipandnavigation 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 hazardousandmightresultincorrosionofthepanelframe.Ontheotherhand,usingtheself-cleaning hydrophobic SiO_2 nanomaterial 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 nanometric hydrophobic coating on the electrical parameter of the photovoltaic panel [6].

1.1 Site Description and Climate

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 Central Arid Zone and Research Institute, Jodhpur at the geographical situation 26.249 latitude and 72.996 longitudes. Jodhpur located in state of Rajasthan in India

II. MATERIAL AND METHODS

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 $37^{o.}$ The first photovoltaic module considered as reference panel and the second one testing panel which was coated with SiO_2 hydrophobic solution film.

Figure 1. Diagram of photovoltaic Panel

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.ThesolarphotovoltaiccollectorsareofEIL 40type,manufacturedby Exide Industries Ltd.Table 1, presentedthemaintechnical characteristics ofthecollectors. 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 as Pyranometer:Davis6450 and digital current and voltage meter. Thepyranometeris mountedontheadjustableplatformandhasaconversionfactorof157mVper1kW/m^2ofsolarirradiation. A dataloggerregistersmVreadingsreceivedbythePyranometerandthermocouplesandconvertsthemtoirradiationin(W/m^2)and temperature in°C.

Table 1.Maincharacteristicsofthe photovoltaicpanels

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

In this study, a comparative analysis was performed for two identical Solar PV panels; the first panel was uncoated and cleaned manually on a daily basis and the second panel was coated with hydrophobic SiO_2 nanomaterial and was therefore considered to be a self-cleaning panel.

Figure 2. Spray coating on Testing Panel

The influence of the hydrophobic layer of the performances of the solar photovoltaiccollectorswasevaluatedbycomparisonbetweenthevaluesofelectricalparametersofperformances. 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)

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

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=0.646$m^2$is the area of the glazedsurface ofthe collectors

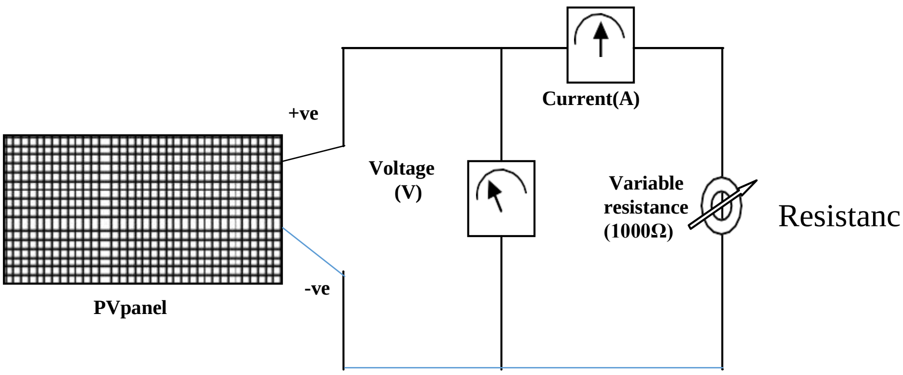

Figure 3 :Variableresistancecircuit.

The I-V characteristics curve of a PV panel at standard conditions (1,000 W/m^2 irradiation and ambient temperature25°C)isprovidedwiththemanufacturerspecificationsheet.However,theseI-Vcurvesatconditionsotherthanstandardconditions can be measured following the procedure developed in an experimental test. The test procedure for theseunitsisasfollows:

1. ConnectthePVpanelunitwiththevariableresistancecircuitasshowninFigure3.
2. Connecttheammeterinserieswiththevariableresistanceand PVpanel.
3. Connectthevoltmeterinparallelwiththevariableresistanceand PVpanel.
4. Adjust the tilt platform and/or rotating stand to achieve the required irradiation, while PV surface temperature is atsteadystate.
5. Measuretheincidentsolarirradiation,PVpanelsurfacetemperatureandambienttemperature(usingthedata).
6. FindaPVpanelshortcircuitcurrentI_{sc}(minimumresistance,maximumcurrentandminimumvoltage)andanopencircuitvoltageV_{oc}(maximumresistance, minimumcurrentand maximumvoltage).
7. Changetheresistanceslightlyfromthevariableresistanceknobandtakethereadingofcurrentandvoltage.
8. Changeirradiationandmeasurementsbyrepeatingsteps4to7.
9. FindthepowergeneratedateachloadfromOhm'slaw(VxI).Maximumpowerpoint(MPP)isfoundfromthepeak point ofthe powervoltagecurve at V_{mp}andI_{mp}.
10. Findtheoptimumoperationloadresistance(R)in(Ω)fromOhm'slaw,whereR=V/I.

III. RESULTS AND DISCUSSIONS

The study refers to the experimental investigation of solar photovoltaic collector's behavior when the glazed surface is treated with a nanometric layer of hydrophobic solution. The experiment was carried out on two photovoltaic collectors, of which one was considered as reference and the other one was coated with a commercial hydrophobic solution. It was studied the evolution of the following electrical parameters; current, voltage, power and efficiency.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 step 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.

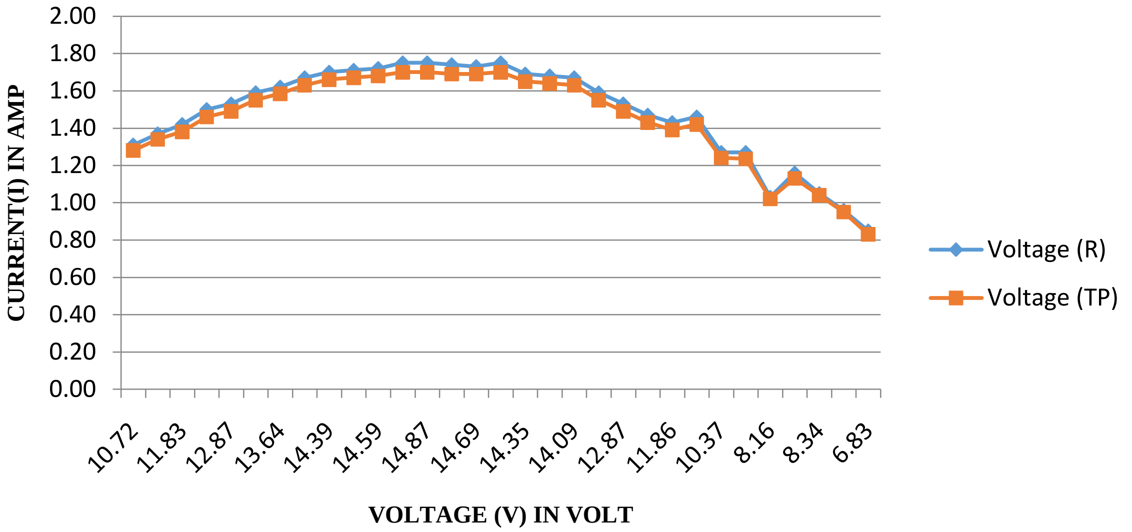

Figure 4. Variation of Current and Voltage of Reference Panel and Coated Panel

- As we find that peak time solar radiation was 869 W/m^2 and nadir time solar radiation was 545 W/m^2.
- The hydrophobic solution determined a current drop of (0.95 – 2.87) % representing performance shift down.
- The hydrophobic solution determined a voltage drop around 3.00% representing performance shift down.
- The hydrophobic solution determined a power drop of (4.02 – 5.75) % determined by the current decreases and representing a performance shift down.
- The hydrophobic solution determined an efficiency drop of (0.38 – 0.58) % determined by the power decrease and representing a performance shift down.

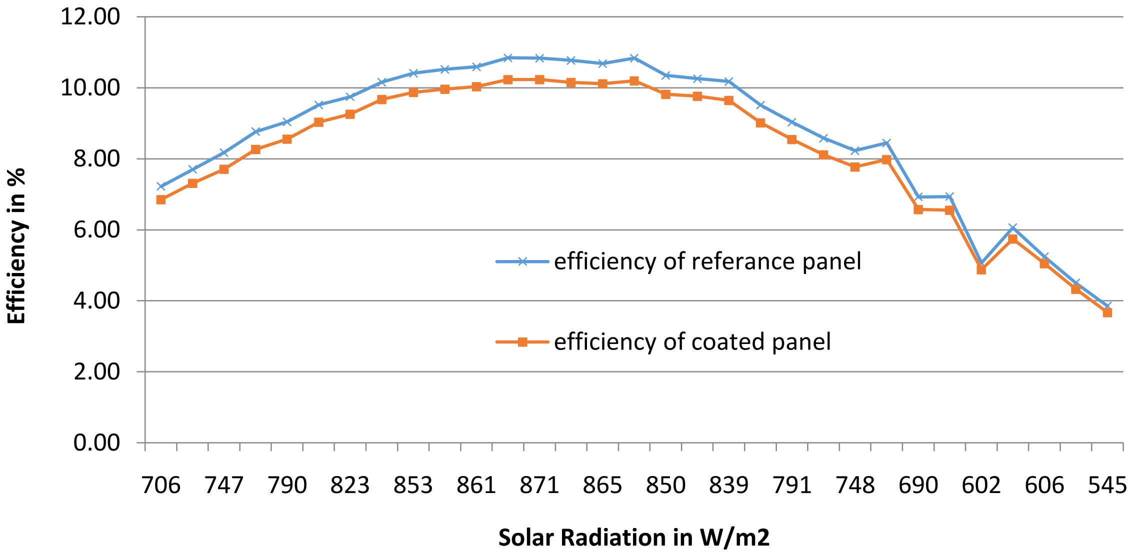

Figure 5. Efficiency of Reference Panel and coated testing

- The hydrophobic solution determined a cumulated power drop of 5.80% representing performance shift down.
- The hydrophobic solution determined a cumulated efficiency drop of 0.64% representing performance shift down.

The current drop with (0.95 – 2.87) % 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 – 5.80) % is mainlydue to the current drop. The efficiency drop of (0.4 - 0.64%) % in absolute values is alsorepresenting a significant deterioration of collectors performance capability.

IV. CONCLUSIONS AND RECOMMENDATIONS

The current drop with (0.95 – 2.87) % 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 – 5.80) % is mainlydue to the current drop. The efficiency drop of (0.4 - 0.64%) % 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.Following this preliminary study, it results as a practical conclusion that the use ofhydrophobicsolutions,forthetreatmentofglazedsurfacesofsolarcollectorsisrecommended, mainly because of panel with dusting particles are inefficient. This conclusionapplies solar photovoltaic collectors. In order to confirm thisconclusion, it isneeded to continuewithdetailedinvestigation.

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