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Review on Dust Cleaning Techniques on Solar Panels

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Abstract - In recent times with the depletion of fossil fuels, renewable energy sector especially solar energy has seen a growth in many areas such as solar powered batteries, solar photovoltaics, solar thermal collectors etc. World is shifting towards the green energy. Solar photovoltaics which is primarily used for generation for electricity, has also seen an increase in efficiency with the usage of new materials such thin film, organic, perovskite, quantum dot solar cells, but there has been a concern about the accumulation of dust which intern reduces the efficiency of the solar photovoltaics. Researchers have developed many ways in order to clean the dust, reduce the possibility of the dust adhesion. This paper gives a review of the dust cleaning ways which intern if applied can increase the efficiency of the solar panels.

Key Words: Solar Photovoltaic, Dust, Self Cleaning, Nano films.

1. INTRODUCTION

Solar Energy is classified into two types, Solar photovoltaics and Solar thermal collectors. Solar photovoltaic uses the photovoltaic effect for the generation of electricity. Solar photovoltaic converts sunlight directly into the electricity with the help of semiconductor this effect is called photovoltaic effect. Solar thermal collectors collects heat by absorbing the sunlight which intern is used for heating applications.

The investment towards the solar energy projects has a rise in many countries such as India, China, USA, Africa etc. There has been the challenge of the dust accumulation for solar panels. The projects that are in the desert regions has seen decline in the efficiency because of the adhesion of dust. Mahfoud.[1]studied the electrical, thermal and optical characteristics by experimenting on a solar panel having nominal output of 20 watt, short circuit current and short voltage 1.26amps and 21.7Volts which led to the conclusion that lower the density of dust on the glass leads to an increase in the transmitted light. This can increase the chances of hot spot effect. Hot spot is an overheating of the solar cell that causes respective cell operating current lower than the entire photovoltaic module. The experiment also concluded that Ash and soil are the unwanted particles that causes the overheat of the module. Yingya chen.[2] Conducted an experiment with solar panels having clean surface and dust surface. Three different dust samples were taken based on density of $10g/m^2$, $20g/m^2$ and $30g/m^2$. After testing, it was concluded that dust has major effect on short circuit current than open circuit voltage. The $10g/m^2$ density of dust accounted 34% decline in efficiency of solar panel. It is seen that with higher dust density there is more decrease of the panel efficiency.

2. LITERATURE REVIEW

The dust accumulation has certainly become a challenge for large solar power project. Researchers have developed techniques in order to minimize the dust adhesion on the solar panel. Following are the ways

1. Natural removal of dusts from the surface of the solar panels.
2. Electrostatic precipitator for removal of dust.
3. Nano film coatings.
4. Mechanical removal of dusts.

2.1 Natural removal of dust

The Natural removal of dust is governed by the natural forces such wind, gravitation, rains etc. Mathew K. Smith .[3] Experimented on the monocrystalline silicon solar panel having an angle of tilt of 30°. Solar panel undergone through 17 day dry spell in midsummer and recorded decline in PV output by 4%. After 28 days rains were capable of restoring the power output by 1%. The effect of natural removal of dust has shown a decline in output. Depending on this method is not reliable, as the suitable weather is not guaranteed.

2.2 Electrostatic precipitator

Hiroyuki Kawamoto.[4] Manufactured a small device as shown in Fig.1.a,b,c. This small device is used for investigating the basic performance of the system. The device had following configurations length 500mm, width 200mm, electrodes made of copper and coated with polyester film with diameter 1mm and thickness 5mm, pitch between the wires of screen electrode is 5mm. This device is placed on the solar panel with dust deposited on the surface. The lower screen of electrode of the electrode is contact with dust particles. The experiment was conducted with temperature range between 20–25 °C. Experiment resulted that at low frequency and high voltage the cleaning performance was high. There is also an increase in the cleaning performance with the inclination was high. The effect of repeated operation was also studied in the experiment. The cleaning performance was not 100%, small dust particles were present. It has been observed that the cumulative dust particles is much smaller than that without cleaning.

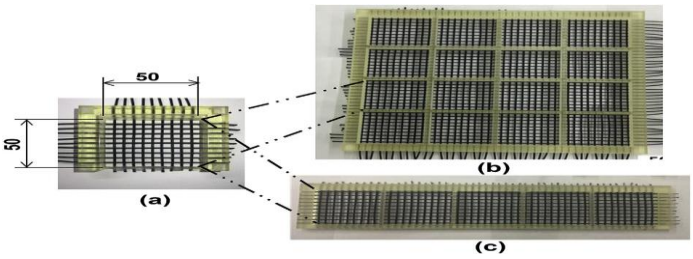

Figure-1 Cleaning device with parallel screen electrode

2.3 Nano film coatings

In this type of technology a whole solar panel is coated with an nano films. These nano films are of two types 1] Super hydrophobic and 2] Super hydrophilic. Both of these coating have different chemical composition. Following are discussed below.

1. Super hydrophobic films

Super-hydrophobic films have contact angle greater than 150°. Ping Wang .[5] Experimented the silicon and fluorine based super hydrophobic films on solar panel. For this experiment red soil particles with an diameter of 25 µm were selected. Wavelengths were also varied during the test. As shown in the Fig.2 After the experiment transmittance vs wavelength shows that transmittance is increased when panels are coated with super-hydrophobic films. This is because the coating has antireflective microstructure that reflects the only the part of sunlight and the remaining is multi reflected to the inside of PV module. Fig .3 shows the microstructure of the super-hydrophobic films.

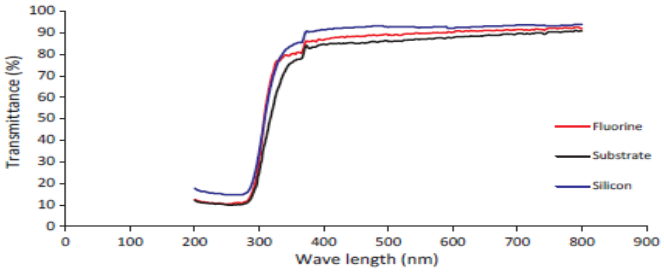

Figure-2 Transmittance Vs Wavelength

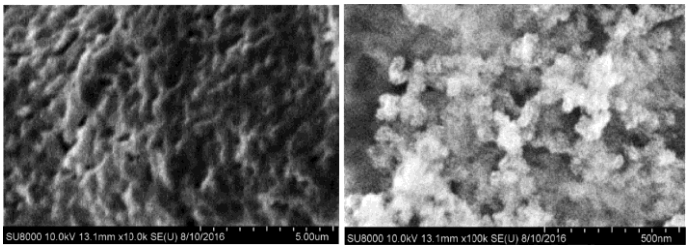

Figure 3 Microstructure of antireflective coating

2. Super hydrophilic films

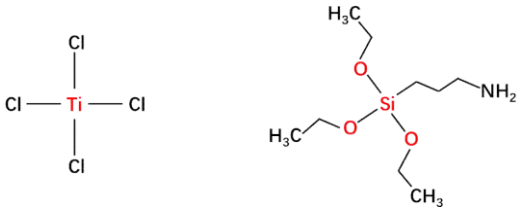

Figure-4 Structure of TiCl4 and KH550

Super hydrophilic films have contact angle lower than 10°. Zhong Hong .[6] Composed a self cleaning super hydrophilic film which is made of 3-triehoxysilylpropylamine (KH550) and TiO2. Structure of the compounds are shown in Fig 4.

The PV panel was coated with super-hydrophilic film and following results were observed as shown in Fig 5. There are low secondary particle size which in turn has increased the transmittance.

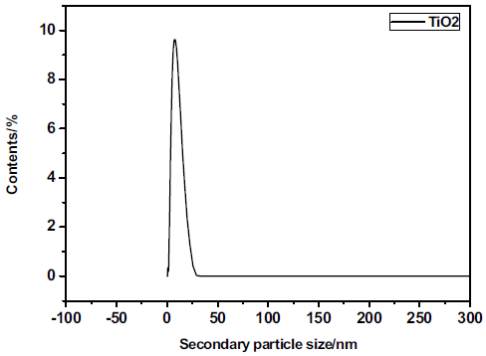

Figure-2 Contents Vs Secondary particle size/nm

2.4 Mechanical removal of dusts

The mechanical methods consist of many different ways of cleaning such as blowers, brushing, compressed air cleaning. By using this method there is a chance of damage and scratches on the solar panel surface. Recently robotic applications have been developed which can combine

multiple operations. These automated robots can eliminate the high labor cost.

Brian Parrott.[6] Experimented automated robotic cleaning integrated with a silicon rubber brush on a 10KW PV system having an angle of tilt of 25°. As shown in Fig 6 PV modules were arranged in three rows with 240modules each. Silicon rubber brush had dimensions 60mm×60mm, with T grooves on its four sides. In this T grooves silicon rubber foam with 6mm thick were inserted.

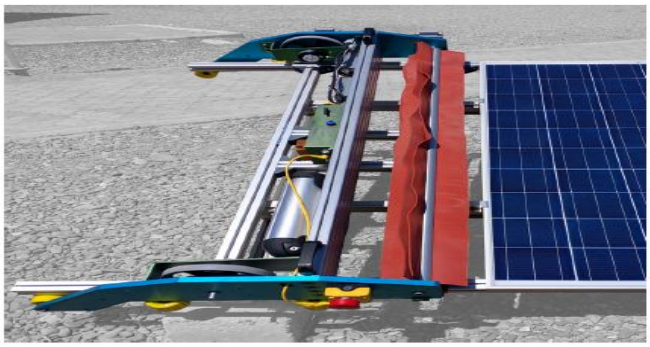

Figure 3 Robotic cleaning system installed in test field

The experiment concluded that due to high effectiveness of silicon brush there is increase in the performance efficiency by 3%.

R.Sreega .[7] Developed a automated solar panel cleaner and cooler. The device consisted of solar panel, Temperature sensor, Dust sensor, Servo motor, Wiper and Arduino Uno. Whole system was integrated as shown in the Fig 7. A suitable algorithm was designed. After testing of the model, the design proved to remove the dust from the surface of the solar panel.

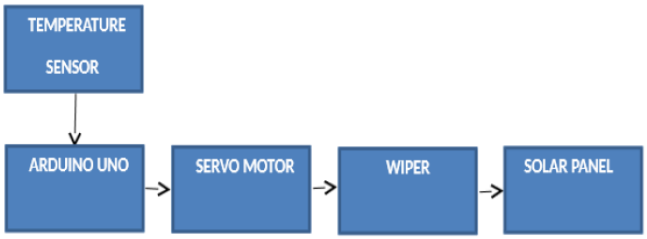

Figure 4 Block diagram of the system.

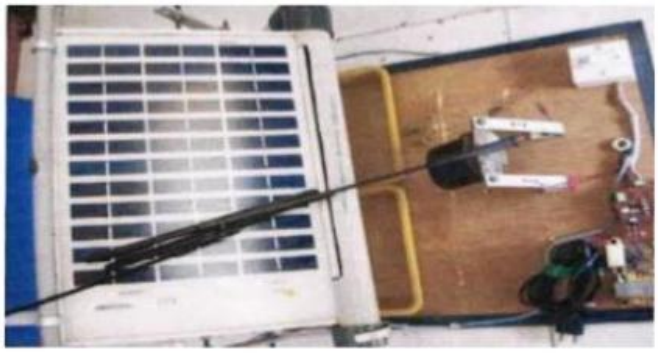

Figure 5 Design of the automatic solar panel cleaner.

3. CONCLUSION

The PV industry has been facing the challenges of dust accumulation since many years. By implementing the above methods the dust adhesion can be reduced drastically. Many developments are going on towards nano film coating and low cost automated robotic cleaning technology. Above technology cannot guarantee 100% removal dust, but has the ability to minimize the dust level on the solar panel and increase the efficiency of the solar panel.

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