Review of cleaning methods for solar cell array

With the fossil fuels in the verge of exhaustion, the renewable sources are being seen as the prospective potentials for energy, the solar photo voltaic technology is one such source that can look up. One of the problems in installing solar energy is pollution/dust and reduces the efficiency of the photovoltaic cell and major power loss when unwanted obstructions cover the surface of the panels. The obstruction turns the shaded cell into a resistor, causing it to heat up and consume extra power. There is urgency in improving the efficiency of solar power generation, to address this issue, we have discussed about self-cleaning solar panel, and different types of mechanical cleaning technology for solar panels in this paper.

A transparent electrode material such as indium tin oxide delivers an alternating current to the top surface of the panel. As it swings between being positively and negatively charged, it creates an electric field that repels charged particles/dust.

A fully automated, simple mechanical design use a rotating brush made up of soft microfiber in conjunction with air blowers which will remove all dust without water and without scratching.

A nano-coating with hydrophobic and self-cleaning properties for photo voltaic panels, the coating's effect stops dust and bird faeces from sticking to PV panels, keeping them clean, maintaining their efficiency.

Keywords: Cleaning methods, solar cell, photo voltaic panels, sunlight, photons, cleaning technology.

1.0 Introduction

Solar energy is the most abundant, inexhaustible and clean of all the renewable energy resources till date. The power from sun intercepted by the earth is about 1.8×1011MW, which is many times larger than the present rate of all the energy demand. Also India being located in the equatorial belt of the globe, thus receiving best radiation from the sun varies from 5.8 to 6.8 kWh/m^2/day, the equivalent energy potential is about 6000 million GigaWatthour of energy per year. The highest annual global radiation is received in Rajasthan and northern Gujarat. A recent report by the International Renewable Energy Agency reveals that solar power is set to transform global electricity generation systems, with the share of electricity generated from solar panels estimated to reach almost 13% by 2030, from 2% in 2016.

Photo electric effect was first recognized in 1839 by F. C. Becquerel. In 1883 first solar cell was built by coating selenium with extremely thin layer of gold. In 1958 Bell laboratories found that silicon doped with certain impurities was very sensitive to light, this finding resulted in the production of first practical solar cell with sunlight conversion efficiency 6%. Nowaday's the efficiency has been increased to 27 to 41%.

Solar installations can be built relatively quickly, often in 6 to 12 months, compared to hydro and fossil fuel projects that require more than 48 to 60 months to complete. This presents a major incentive in rapidly growing, emerging markets with a high unmet demand and urgent need for power. Assuming that photo voltaic (PV) technology prices continue to fall relative to competing sources of electricity, the market penetration rate of utility scale solar power projects can be expected to continue growing rapidly, including in emerging markets.

2.0 Principle

Sunlight is made out of tiny energy pockets called photons and that each individual solar cell is designed with a positive and negative layer thus being able to create an electric field. As photons are absorbed in the cell their energy causes electrons to get free, and they move to the bottom of the cell and exit through the connecting wire which creates flow of electrons thus generate electricity. The larger amount of the available sunlight is greater will be the flow of electrons and more electricity gets produced in the process. Photo voltaic conversion is the direct conversion of sunlight into electricity without any heat engine. PV devices are rugged and simple in design requiring very little maintenance and their advantage is their construction as standalone systems to give outputs from microwatts to gigawatts. Hence they are used for power source, remote buildings, satellites and space vehicles. Materials presently used for photo voltaic include

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mono-crystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride and copper indium gallium selenide.

3.0 Problems

The problems with installing solar energy are high capital cost, large land area requirement, power storage is incredibly expensive on a large scale, and the main problem with installed solar energy is dust accumulated over the solar cell, reducing the efficiency of the solar cell. In this paper we are discussing about the cleaning technologies available and merits and demerits of the techniques.

The solar plant located in mines area or in desert areas where dry weather and winds sweep dust into the air and deposit it onto the surface in these areas, making it expensive to clean the solar panels. It is reported that a dust layer of 4 gram per square meter decreases solar power conversion by 40%. The cleaning methods are summarized as follows

1. Natural powers
2. Manual cleaning
3. Self-cleaning by electrostatic principle
4. Mechanical design
5. Nano-coating

4.0 Natural powers

Natural powers are employed to remove the dusts, such as gravitation, wind power and scour of the rainwater. Occasional gust of wind have cleared off the solar panels, but we may not be lucky all the time. Also the solar cell array can be turned to vertical or oblique position to remove the dusts easily when early morning, late evening, night and a rainy day. However the effect of this method is not very well and difficult and dust particles left more than a day adhere to the panels.

5.0 Manual cleaning

Human labour can be used to clean the dust accumulated over the solar panels, with the help of water based cleaning solutions, but there are so many drawbacks in this method. Expensive, unreliable human labour in harsh, remote desert conditions (solar located near desert). The sun is so harsh and conditions so inhospitable, and the nights so hot, that any manual labour component will be a primary source of failure.

6.0 Self cleaning by electrostatic principle

This system takes advantage of the fact that most dust particles, particularly in dry environments, have an electric charge. A transparent electrode material such as indium tin oxide delivers an alternating current to the top surface of the panel. As it swings between being positively and negatively charged it creates an electric field that repels positively and negatively charged particles, as is shown in the Fig.1. The electric field also helps to impart a charge to uncharged dust particles, allowing them to be quickly repelled as they come in contact with the panel.

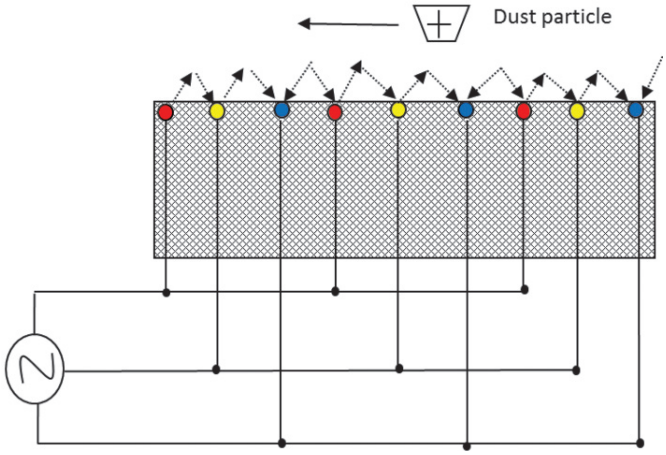

Fig.1: Three phase electric curtain

The researchers have designed the system so that the electric field works its way from one side of the solar panel to the other, gradually moving the dust along until it falls off.

This system does not use much energy, typically it only needs to be on between two and five minutes a day. The system could include a sensor to determine when the panel needed cleaning. The technology does not work if the dust gets wet and muddy, so it should be triggered to remove dust before it rains.

7.0 Mechanical design

The mechanical methods remove the dusts by brushing, blowing, vibrating and ultrasonic driving. The brushing methods clean the solar cell with something like the broom or brush, designed just like windscreen-wiper, that were driven by the automation. The blowing method cleaning the solar cell with wind power is an effective cleaning one as is shown in Fig.2.

Fig.2: No water automated mechanical dusting device

Fully automated robots are mounted on a frame that moves laterally along the panels and the robots themselves move up and down the panels. The cost effective guiding rail system ensures that no pressure is applied to panel surfaces and the system translates smoothly across the array for the lifetime of the array. They use a rotating brush made up of soft microfiber in conjunction with air blowers to remove dust over the solar panels. This approach means that no water is required, also robots use their own solar panels energy shown in Fig.3. This method is cost effective, waterless operations, able to survive harsh conditions.

Fig.3: Robot for cleaning solar panels

8.0 Nano coating

A nano coating with hydrophobic and self-cleaning properties for photo voltaic panels stops dust and bird faeces from sticking to PV panels, keeping them clean, maintaining their efficiency, ensuring the maximum amount of electricity is produced. The hydrophobic properties repel water more quickly, drastically reduces cleaning frequencies, can be applied from –25 to +80 degree celsius. This coating has resistant to salty air, reduces the growth of micro-organisms and bacteria.

The principle behind a hydrophobic coating is that the layer forms a barrier so that water accumulates on the surface in an almost spherical shape, but is blocked from adhering to the surface by the barrier. When a treated surface is tilted at an angle, the water rolls off the surface like a sphere rolling down a slide, clearly we can see from the Fig.4. As the water is repelled by the treated surface it will also pick up and carry away the dust and dirt, thereby cleaning the panel naturally.

9.0 Conclusions

Photo voltaic cells which can provide renewable and clean energy by converting sunlight to electrical power have attracted much attention in the past few years. The aim is to minimize losses, reducing the total loss increases the annual energy yield and hence the revenue.

Solar panel located in desert area, water is a precious, energy intensive commodity, and is not always readily available. It must be transported, and more is always needed

Fig.4: Nano coated solar cells

than expected. Any water-based cleaning solutions will always be prone to breakdown if water supplies are interrupted or become more expensive. For this type of solar energy where rain fall is a rare occurrence we can use self-cleaning electrostatic method to remove dust from the solar panel. Also no water automated mechanical dusting devices can be used.

Solar panel located in other than desert area where average rainfall will be varied from 2mm to 190mm, we can use nano-hydrophobic coating combined with automated mechanical dusting device/robot to remove the dust over the solar panels efficiently.

It is the skill of the plant designer to make suitable compromises that result in a plant with a high performance at a reasonable cost according to the local conditions. The ultimate aim of the designer is to create a plant that maximizes financial returns by minimizing the levelised cost of electricity. Despite the growing importance we need to reduce the cost of the PVs and increase the energy conversion efficiency before they can successfully replace fossil fuel for electrical power generation.

Although some methods of cleaning the solar panel have been discussed in this paper, the best strategy of removal-dusts for solar cell array is electrostatic method which is now used in satellite for Mars mission. Rather than its technical and economic limitations at present, it is expected that solar energy will play an important role in the future.

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