IMPROVING THE EFFICIENCY OF SOLAR PANEL SURFACES BY CLEANING METHODS AND MONITORING THEM

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Annotation: *This article covers ways to improve the efficiency of its electrical energy production by cleaning the surface of solar panels from coated dust particles. This includes self-cleaning and solar panel monitoring system, automatic cleaning of solar panels based on microcontroller, electrostatic dust removal, mechanical cleaning methods, electrostatic dust removal methods, from which electrostatic dust removal methods have been analyzed to be more efficient than other methods.*

Keywords. *Solar panel, electrostatic method, pollination, microcontroller, self-cleaning and cleaning system, mechanical cleaning.*

Solar energy is one of the clean and renewable energy sources. Solar energy has experienced remarkable growth in recent years due to technological improvements that have led to cost reductions and government laws and resolutions supporting the development and use of renewable energy have been passed, In this regard, the decree of the president of the Republic of Uzbekistan dated February 16, 2023 “on measures to accelerate the introduction of renewable energy sources and energy-saving technologies in 2023” PQ-57 was adopted, and the Order of the Cabinet of Ministers of the Republic of Uzbekistan dated June 14, 2023 “on establishing the procedure for the sale of excess of the decision was made. An additional 5 mld in 2023 through the installation of renewable energy devices, the transfer of consumers to alternative energy and the introduction of energy-efficient technologies according to the draft resolution. kW * h electricity generation and economy of 4.8 billion m3 of cubic natural gas are envisaged. In addition, individuals and legal entities who have installed renewable energy devices with a total capacity of up to 100 kW pay a profit tax on these devices, a land tax on plots occupied by devices and a profit tax calculated from the profits received by legal entities for electricity sold to the general network for a period of 3 years from the moment they, if installed with an electrical energy storage system with a capacity of no less than 25% in relation to the capacity of the installed solar panels-it is exempt from taxes for a period of 10 years;

In addition, since April 1, 2023, it is not required to obtain an additional technical condition when connecting renewable energy devices to electrical networks, which is not higher than the capacity specified in the technical conditions provided for connecting to a single electric power system.

Due to the increased demand for energy at today's stage of World Development, the constant increase in energy prices, the development of modern, environmentally friendly, energy-efficient technologies, as well as green energy using renewable energies, is an urgent issue.

Currently, the scale of the use of renewable energy, especially solar, is increasing worldwide. High-power solar photovoltaic plants have already been installed in countries such as Australia, the Middle East, the United States (USA), Europe and China. This study analyzes the technical, economic and political aspects of solar energy development and deployment. Only photovoltaic (PV, a semiconductor device that transfers solar radiation directly to electricity) devices and panels are mentioned in the article. Although the cost of solar energy has fallen rapidly in the recent past, it still remains much higher than the cost of traditional energy technologies. During the use of built-in solar panels, after a certain period of time, there is a significant decrease in their energy efficiency. This can be caused by several factors. The efficiency of solar panels is also influenced by the climatic conditions of the location of the panels. The manufacturer tests the solar elements and panels in a special laboratory before launching them for sale. Indicators must meet the established standards of the characteristic of solar panels. We will also list the following factors that affect the effectiveness of solar panels. The increase in temperature and the coating of the panel surface with dust is considered. The accumulation of dust particles on the surface of solar panels significantly reduces the efficiency of solar panels.

Factors affecting the dust coating of the Panel surface

• Tilt angle and orientation of the solar panel relative to the horizon;

• Temperature and humidity of the external environment;

• Properties of dust (dust type biological, electrostatic and chemical properties, size, shape, weight);

• Wind speed;

• Characteristics of the area where it is located (local trees, pedestrian and traffic roads and air pollution);

• Characteristics of glass in a Panel surface (roughness of the panel surface, coating properties).

The results and studies obtained show that horizontally mounted solar panels will have a lower efficiency than those installed at 450 degrees compared to horizontal. Humidity, temperature, region of location, wind speed, degree of air desalination also have a positive effect on the pollination of the panel surface. In addition, the biological, electrostatic, chemical properties of dust particles, their shape, size and weight are among the factors that lead to dust accumulation. The loss of power due to pollination also varies depending on the physical and chemical properties of the dust particles and geographic location.

Analysis of methods for cleaning surfaces of solar panels

The self-cleaning and solar panel monitoring system developed a prototype system to improve efficiency, including a self-cleaning and monitoring mechanism for solar panels (Figure 1). This model consists of constant electric current motors for cleaning and monitoring,

respectively. The system also has a microcontroller that helps to automatically monitor and clean panels.

Figure 1. Solar photovoltaic station with self-cleaning and foiling system.

A microcontroller receives information from light-dependent resistors (YBZS), and based on this, a panel cleaner and sun-tracking resistor commands permanent direct Motors. The value of light-dependent resistors is based on light illumination. If it is dark, the Resistance increases, and with illuminated light, the resistance decreases sharply. They also developed an algorithm for panel cleaning and solar monitoring [4]. Table 2 below gives details of efficiency under different test conditions.

System parameters	Dusted solar panel with observation mechanistic dusted	Dusted solar panel with no observation system dusted solar panel	Pollinated solar panel with tracking system non-pollinated solar panel	Pollinated solar panel with no tracking system
Maximum power P_{max} [W]	7,48	6,39	3,99	2,819
Useful work factor η, %	7,13	6,08	3,8	2,653

Automatic cleaning of solar panels based on a microcontroller-proposed by a robot that acts as an automatic cleaning agent for the solar battery [5]. The robot has brushes that match the size of the solar panels. The robot can also adapt to clean panels of different sizes. Strap-on fixed-current motors drive brushes (Figure 2).

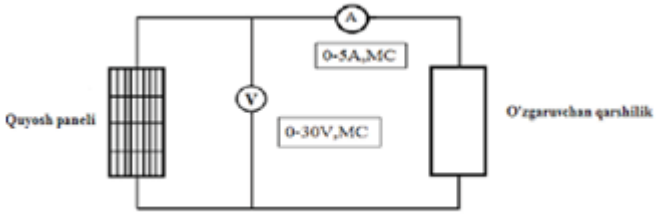

Figure 2. Block diagram of a microcontroller-based automatic cleaner

Electrostatic dust removal-one of the methods of electrostatic removal of dust particles by an electrostatic method is the electrostatic method. Gaofa proposed two mechanisms for charging particles on the Moon.

1) electrons emitted from the surface of particles by photoemission under the influence of Ultra-violet radiation

2) triboelectric charging. When there is a high potential on the surface of the solar panel, the panel attracts free and charged dust due to electrostatic forces.

The solar panel charges dust particles. Since their electric charges are the same, there will be a push between them due to the electrostatic forces between them. Finally, dust particles fly away from the solar panels. Due to the effects of rain, this method has limitations in the solar panel system. Another effective electric dust removal method is the electric curtain method.

Mazumder et al [6] took q as the electrostatic charge on the particle. According to experimental data, both particles are charged and discharged from the screen (as shown in Figure 3). Particles deposited on the surface of the screen without the initial charge (q=0) will have a clear electrostatic charge. It is the transfer of a particle through dielectrophoresis (polarization of charge) or for a induction charge. Thanks to these processes, the particle is affected by a specific force, which leads to the movement of the particle on the surface of the screen. As a result of dielectrophoretic-triboelectrification, a clear charge is obtained by the particles, which causes a push from the surface of the screen

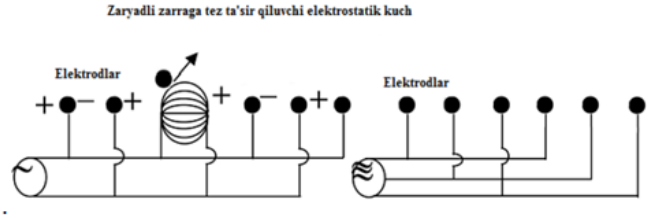

Figure 3. One-phase electric curtain (left side) three-phase electric curtain (right side)

Results from Mazumder et al show that the three-phase electrodynamic screen model increases dust removal efficiency over the single-phase Model. For an electrodynamic screen with an electrode spacing of 1,27 mm in the figure, dust particle cleaning was achieved with an efficiency of 90%. The performance of the electrodynamic screen was analyzed for neutral and charged particles. It was observed that the efficiency of dust removal for neutral particles did not deteriorate for test screens.

Mechanical dust particle cleaning-mechanical dust removal system includes various methods including ultrasonic driving, blowing, brushing and vibration [1]. Mechanical vibrations can remove dust particles by introducing piezoceramic actuators into solar panels. Therefore, the efficiency of solar panels increases by 95 percent.

One of the ways to clean this system is to clean the solar battery with wind energy. It has effective advantages, but at the same time has such disadvantages as high energy consumption, low efficiency and difficulties in the maintenance of the blower. The mechanical cleaning device consists of brush cleaners, like the windshield wipers of the machine. There are difficulties with this method, and since the working environment of solar cells is poor, there are more difficulties with the maintenance of the machine. In addition, this method is ineffective due to the strong viscosity of the powders, and they have small dimensions. The solar battery can be damaged due to brush wiping, and the cleaning machine should be stronger as the solar battery area becomes larger.

In conclusion, scientists are currently doing a lot of research to improve the efficiency of solar panels. In turn, there are more than 10 ways to remove accumulated dust particles on the surface of the panels.

The result of the studies shows that one of the most effective methods of cleaning dust particles on the surface of the solar panel is cleaning using electrosatic force. This is because it has been observed by studies that the effect of cleaning dust particles on the panel surface is much higher compared to other methods.

It can also be much more effective to use this method for photovoltaic plants located in more desert zones. We know that the level of pollination in desert zones is considered much higher than in other regions.

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