Dust removal device for waterless solar photovoltaic panel

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Abstract. With the rapid development of human science and technology, energy consumption is becoming increasingly severe, and solar energy, which is one of the clean energy in the future, has attracted wide attention. However, while solar photovoltaic power stations bring huge economic benefits, a huge problem about the cleaning and protection of solar photovoltaic power generation panels has also arisen [1]. The photovoltaic module is exposed to the air for a long time, and the dust falls on the surface of the photovoltaic module, blocking the light from entering, and reducing the light conversion efficiency of the photovoltaic module. It is urgent to deal with cleaning problems. This project intends to design a solar panel dust cleaning device that is mechanically cleaned by a brush and adsorbed by a chemical synthetic glue in the absence of water. To a large extent, it solves the problems caused by uncleaning, saves the use of water resources, and avoids the pollution of impurities brought by clean water washing.

1. Introduction

In October 2017, the five ministries and commissions issued the "Guiding Opinions on Promoting the Development of Energy Storage Industry and Technology", which for the first time clearly defined the strategic positioning of energy storage, and put forward China's energy storage technology and industry development goals for the next 10 years. The ash contamination of photovoltaic power generation panels is an important reason that currently affects its power generation efficiency. Studies have shown that "4g/m² dust will reduce the efficiency of solar panels by 40%" [6], so it is urgent to deal with cleaning problems. However, There are many problems with the current major solar panel cleaning methods [2] [5].

1. Natural dust removal method, which uses the realization of rain and wind in the natural world, is suitable for areas with abundant rainfall in a small area, but it is obviously unrealistic for such areas in the Northwest China that are short of water and have severe sandstorms.

2. The machine uses air to blow dust, and uses high-pressure air to blow dust in a wide range. However, its high precision installation of the instrument and the impact of this method on the solar panel are relatively large, which may damage the battery panel.

3. Vehicle-mounted mobile cleaning machine, the cleaning efficiency of the machine is high, can reach 6 times the manual cleaning speed. This machine may be able to effectively adapt to the natural environment in the west and save water, but the cost is high and it is not suitable for large-scale promotion.
This product fills the blank of dust cleaning of solar power generation panels in large photovoltaic power panels in China, realizes continuous and efficient work of solar power generation equipment, and has great economic benefits. The combination of the two cleaning methods achieves an effective treatment without causing damage to the solar power generation panel, and avoids the economic loss caused by the light spot effect. At the same time, water resources are not directly involved, which is also adapted to the current situation of water shortage in the Northwest. The use of this product will completely solve the embarrassing situation of dust treatment of solar power generation equipment in China. [4]

2. Concept Design
This device is a new type solar panel cleaning device which combines mechanical dust removal and adhesive dust removal. Achieve an ultimate dust removal effect without consuming water. It also has great advantages in sustainable use. This product has a simple structure, high efficiency, obvious effects, simple use, and is very suitable for this climate in northwestern China.

Add two metal rails on both sides of the solar panel, and two fixed-spaced brackets on the rails can fix the machine between the rails. The bracket can also be moved along the guide rail at the same time. When the machine is working, the two brackets are on the side of the solar panel. When the machine starts to work, the two brackets move forward at a constant speed along the direction of the guide rail. At the same time, the machine starts to work and can remove the dust on the solar panel. When the bracket reaches the other end, cleaning is complete.
3. Structural Design

3.1. Laying of rails
The guide rails and brackets are driven by roller-type guide rails. Similar to the way of rails, the guide rails are laid on the metal frame of the solar panel. The rollers on both sides of the bracket are placed on the guide rails and fixed to prevent sliding. The rotation of the roller is driven by the motor, and the translation of the bracket on the guide rail is realized by the rotation of the roller. And you can choose the number of machines according to the length of the bracket. In this way, each solar panel can be completely covered during the machine cleaning process.

This machine is mounted on the stand and moves forward as the stand moves. The equipment is divided into rolling dust sweeping structure and dust-removing rubber dust-removing structure that can be cleaned repeatedly and equipped with automatic cleaning device. When the machine starts to work, the rolling brush in the front starts to work, and the first step is to sweep the dust. The sand and dust on the solar panel are preliminarily cleaned to expose the solar panel for the second step. Subsequently, on the panel cleaned by the brush, the dust-removing glue and dust-removing device that can be repeatedly cleaned will completely remove the remaining dust.

3.2. Brush structure
The rolling dust sweeping structure consists of a rotatable roller and a bristle brush. Due to the unique wind and sand in the northwest region, this attachment state is relatively loose in the environment that has just started to dry, and it can be cleaned directly with a special brush. Therefore, a roller of the brush is provided in the device to achieve the preliminary cleaning effect. The second serious impact is scale. When dust adheres to the surface of photovoltaic modules, it encounters humid air or rain, and the stickiness between the particulate matter and the solar panel becomes strong after the damp, and the accumulation of the pieces becomes points, pieces, and stripes. It is relatively hard, and dust in this form is more difficult to remove. The bristles brush can completely pre-treat this situation. The bristle brush is fixed on the roller, the outer bristles of the bristles are brushed, the inner tube wall is nylon, and the pigskin is punctured on the nylon tube wall. The roller brush is punctured alternately with soft and hard, which can produce a large Mechanical force. According to the deformation obstacle of the roller brush bristles, the longer the bristles, the easier it is to get over the obstacles, but too long will reduce the
sensitivity of the cleaner. The bristles should be symmetrical to the center of the drum, left and right to puncture symmetrically. The frictional force on the glass surface removes large dirt, so the photovoltaic surface after cleaning is relatively clean. And this process can also remove some dust such as sand and dust on the solar panel without water treatment.

3.3. Treatment structure of dedusting glue

The dedusting glue treatment structure, which can be repeatedly cleaned, is an isosceles trapezoid track with one-way opening. Inside, there are two rotating shafts linked by track. At the beginning, one of them is filled with clean usable dedusting glue. When the equipment starts to move, the synthetic glue is completely covered on the outer surface. As the bracket moves forward, the usable dedusting glue which on the top moves from one rotating shaft to the other through the whole outer surface. Thus, the cleaning effect of the synthetic glue on the whole solar energy surface is achieved. This re-cleanable dust-removing adhesive is the most common type of re-usable dust-absorbing film in the market. A plastic film with high tensile strength is added to the upper surface. After use, it can be reused after simple cleaning. Reusable up to 10,000 times, and low cost.

4. Experimental verification

In order to verify the cleaning efficiency of the device, the experiment is carried out. In the three sites of 10×10m, the same amount of solar photovoltaic panels are placed, and a considerable degree of dust adhesion is artificially manufactured. Conduct manual cleaning, machine blowing and the device cleaning respectively. Under the same experimental conditions, the experiment was carried out, and the results showed that the efficiency of the new device was improved by 156.8% and 42.9% respectively compared with that of the manual device and the machine device, and the cleanliness was improved by 52.6% and 32.8% respectively.

In the three cleaned sites, the power generation efficiency test is carried out in time. In the total power generation time of 1 hour, the power generation efficiency of the device is increased by 2.6% and 1.9% compared with that of manual and machine blowing.

Because there are some differences between the simulation of experimental conditions and the actual situation, under the reasonable conversion, the experimental results show that the device can effectively improve the cleaning efficiency of the solar panel, and improve the power generation efficiency.

5. Benefit analysis

In July 012, a 507.6-kilowatt cleaning device was installed at Golmud's “Jingneng” photovoltaic power station in Qinghai, which contained 54 sets of square arrays, denoted as array P1. Compared with the adjacent 517-kilowatt array without automatic cleaning device, which contains 55 sets of square
arrays, recorded as array P2. The "Jingneng" photovoltaic power station was connected to the grid in March 2013. In order to ensure the authenticity and reliability of the data, a three-phase energy meter was installed at the grid side of each inverter room to monitor and record the accumulated power generation. The inverter data is for reference only, and the meter reading is conducted once a day or every two days. At the same time, before installing the cleaning device, the efficiency difference between array P1 and P2 was studied and compared. Before installing the cleaning device, the power generation of P1 is 360683kwh, the power generation of P2 is 386975kwh, 55 groups of P2 are converted to 54 groups of array data (P2') power generation is 379939kwh, P1 and P2 were started to operate in the same period at the end of 2012 (data provided by the owner's monitoring platform and inverter display, in which P1 light utilization hours are 4686 hours, P2 light utilization hours are 4617 hours.

It follows that the power generation efficiency of P2 before cleaning is indeed higher than that of P1). According to the above data, it can be calculated that the efficiency of P2 is 4.98% higher than that of P1 before cleaning devices are not installed. This is due to possible factors such as lighting, differences between component strings, so this difference needs to be added to the reading when calculating the actual efficiency difference. It is recorded as efficiency compensation here. The calculation results are from the comparison data before cleaning. Therefore, when calculating the actual efficiency of cleaning devices, this compensation value needs to be added to be the real value. In remote northwest China, water resources are scarce, and the device can use less water to clean solar panels.

By the end of 2016, the cumulative installed capacity of photovoltaic power generation in China was 77.42 million kilowatts. Among them, the cumulative installed capacity of photovoltaic power station is 67.1 million kilowatts, and the distributed cumulative installed capacity is 10.32 million kilowatts. This product is for photovoltaic power stations. If the entire country's photovoltaic power stations install this product, the power generation rate can be improved:

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67100000 \times 12\% \approx 7.9 \times 10^6 \text{ (kw)}
\]

According to the clean comparative experiment of "Jingneng" photovoltaic power generation in Golmud, Qinghai Province, the power generation efficiency of the experimental group is increased by about 11.82% compared with that of the control group.

According to 6 hours of power generation per day and 250 days of power generation per year, more power can be generated:

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7931220 \times 6 \times 250 \approx 1.1 \times 10^{10} \text{ (kw ∙ h)}
\]

From March 22 to April 24, 29 days (excluding the days of power outage) The solar panels have increased the generating capacity by 10399.68kwh, according to the local electricity price of 1.15 yuan / kWh, and the value-added value is 11959.63 yuan. Among them, it snowed on April 5, and the photovoltaic cell modules in the whole field were very clean, which was equivalent to a manual cleaning. At the same time, the cumulative increase proportion decreased on April 5. The whole field was cut off from April 7 to April 11, and then the increase proportion returned to normal. From the analysis of the current trend, it is expected that the overall increase proportion will be more than 14% by 30 days. At present, Golmud is a relatively clean season (The environment is dirtier in winter), and the weather is also relatively fine. Dust has little impact on photovoltaic power stations, and at the same time, there is less industrial pollution in Golmud, and dust accumulation has less impact on photovoltaic power stations. It is expected that the proportion of increase in winter or in other areas will be slightly higher, which is expected to reach 20% - 30%.

Economic benefits:

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11846830000 \times 1.15 = 1.3710^9 \text{ (Yuan)}
\]
It can supply power for more than 2.83 million households in one year.

6. Innovative design
The innovation of this device is mainly reflected in the following three aspects:
1. The waterless clean solar panel can save water resources and effectively prevent solar panel damage.
2. Through the combination of mechanical dust cleaning and chemical material dust collection, the full automation of cleaning is realized.
3. The mechanical structure of the track and the synthetic reusable glue ensure the sustainable utilization of the device.

7. Conclusion
The data shows that the growth rate of photovoltaic power generation industry in China has reached 100%, and the annual power generation capacity has reached 2 GW in design, which also means that the solar power generation industry in China has a huge loss due to dust. But at present, it is faced with a dilemma: There isn’t enough water resources in the area with the most abundant solar energy resources. They still use the low efficiency of traditional methods, and the high-tech dust removal device cannot be applied to large-scale cleaning in those area.

In this dilemma, the water free cleaning device solves the problem of equipment damage caused by water washing, and the damage caused by pure mechanical cleaning to solar panels is also very small, at the same time, it also saves water resources to a certain degree and has a great market competitiveness. We use orbital placement and reusable synthetic film, which has the advantage of sustainable utilization. This product can be widely used in large-scale solar power plants all over the world. It fills in the gap of large-scale solar dust cleaning industry in China and has great application prospects.

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