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Research on Solar Panel Cleaning System in Frozen Environment for Distributed Photovoltaic Generation

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ABSTRACT: *The solar panel is the core of the solar power generation system, dust particles and special frozen environment will affect the efficiency of power generation, however, the cleaning process of solar panels often encountered operating difficulties, low efficiency, time-consuming and high cost, is proposed and studied the frozen environment of distributed PV module cleaning, operation and maintenance of the wire driven parallel mechanism. The design part of the parallel mechanism, which comprises a bracket part, twisted rope pulley, part part, general configuration and maintenance system under the proposed PV, cleaning roller with heating function, at the same time, based on the parallel mechanism, inverse kinematics analysis of cleaning device on the system, solves the problem of cleaning photovoltaic panels in ice environment.*

KEY WORDS : *solar panels; distributed photovoltaic power generation; photovoltaic cleaning; PV power station operation and maintenance;*

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I. Introduction: Project research background and significance

In order to reduce air pollution, protect the human ecological environment and ensure the long-term stable supply of energy, we must implement a strategy of sustainable development, gradually change the existing energy structure, vigorously develop and utilize new energy sources, and solar photovoltaic power generation has become a relay in the field of renewable energy With the promotion of national new energy policy, China's solar photovoltaic products have undergone a period of development and their output and productivity have been continuously increasing. As far as the supply of photovoltaic modules is concerned, since 2007, the industrialization of wind power has been the fastest growing and largest. , China has become the world's largest producer of photovoltaic modules. In 2013, polysilicon production in China was 84,000 tons, an increase of 18.3%, polycrystalline silicon imports were 80,000 tons, and the production of battery modules was about 26GW, accounting for 15% of the global total Over the same period an increase of 13%. Exports 16GW, exports about 12.7 billion US dollars.

Solar panels are the core part of the solar power system and the most expensive part of the solar power system, as shown in Figure 1. Its function is to convert solar energy into electricity or send energy to the battery for storage or to promote the work load[1]The quality and cost of solar panels will directly determine the quality and cost of the entire system, if you want to increase the efficiency of solar photovoltaic panels 1-2 percentage points, it will spend a lot of research and development funds, dust and frozen solar photovoltaic panels The impact is huge, which will make power generation efficiency low 35% -40%.

At present, there are over 100 enterprises engaged in R & D and production of photovoltaic equipment in China. Most of the factories are located in the eastern, northern and southern parts of China. The distribution of the wafer cleaning equipment market in China also shows a certain regionalization, And the main goal of cleaning equipment manufacturers and the distribution of silicon battery components enterprises, the East China Yangtze River Delta area consumption accounts for only half of national demand, followed by South China, North China, Northwest, Northeast and other regions[2], these companies mainly use expensive Of self-cleaning materials, and dangerous manual cleaning methods, as shown in Figure 2, there are a few companies use automatic cleaning equipment, but only for a single piece of solar photovoltaic panels. It is difficult to meet the needs of cleaning a large number of rows of solar photovoltaic panels in the cold centralized power generation area and has a low degree of automation and can not monitor the cleaning of the panel and the operation status of the cleaning equipment in real time[3]. As of the end of 2015, Power generation total installed capacity of 43GW, becoming the world's installed capacity of photovoltaic power generation, the largest capacity of the country. In the "13th Five-Year Plan for Solar Power Industry Plan" issued by the National Energy

Administration, it is estimated that the installed capacity of photovoltaic power generation will reach 150GW by 2020, of which 70GW will be ground-based and 80GW distributed.

Solar wafer cleaning technology problems in the cleaning process will produce a lot of sticky dust, they will produce residual pulp, cleaning fluid, cleaning fluid and silicon, silicon oxide and other reactants, sticky dust to clean the solar wafer, you must Remove them and clean them with a solar washer. Although the cleaning effect is considerable, it takes a lot of labor and time and labor, which will increase labor costs. Therefore, there is an urgent need to have a structure with a simple, low inertia, translational work space and fast moving speed, can be used in a single row of solar photovoltaic group cleaning,but also can be applied to the solar photovoltaic group under the freezing environmental conditions, which can accomplish the task of cleaning across rows and improve the cleaning efficiency.This paper is aimed at the freezing environment of photovoltaic panels, power generation, Rudong

The heating function is put forward under the conventional configuration of photovoltaic operation and maintenance system.The cleaning drum is also analyzed based on the inverse kinematics of parallel mechanism, and the problem of cleaning photovoltaic panels in frozen environment is solved.

Fig.1 Building distributed solar power generation system

Fig.2.Traditional mechanical cleaning

II. Principle of Cable driven Solar panel cleaning system

Solar panel cleaning system is consisted of Cable driven Design Scheme. This project is based on the previous research of cleaning robot, developed a set of distributed photovoltaic modules, frozen environment cleaning operation and maintenance of the wire driven parallel mechanism, as shown in Figure 3, is mainly composed of a bracket part, twisted rope, pulley part, heating part.

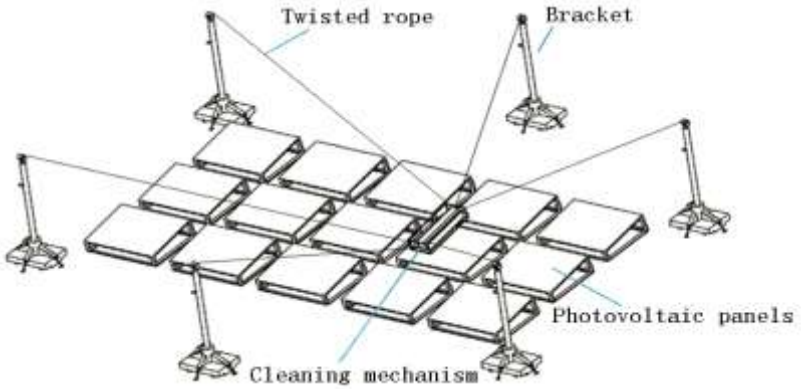

Fig.3 . A distributed solar panel cleaning device for ice and snow environmental rope traction parallel

mechanismAs shown in Figure 4, tere are four wheels at the bottom of each bracket, which can provide steering and power. There are four supports that can rise and fall at the side of the wheel, and the fixed position of the bracket is lowered when the parallel rope traction mechanism reaches the specified position.

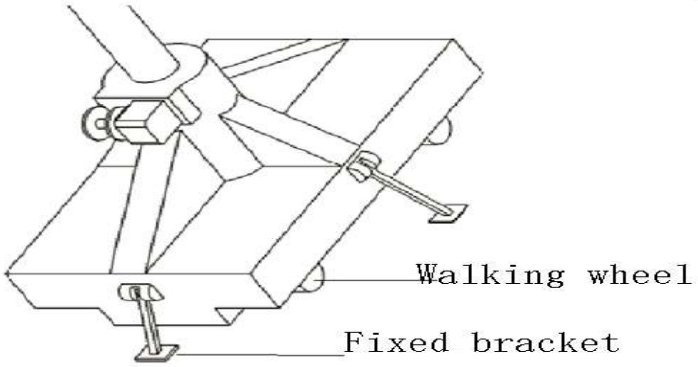

Fig.4 . Bottom bracket of cleaning system

As shown in Figure 5, the winch is used as a driver. Each bracket has a twisted rope mechanism at the bottom position to change the length of the rope, reduce the workspace and guarantee the motion speed of the mechanism.

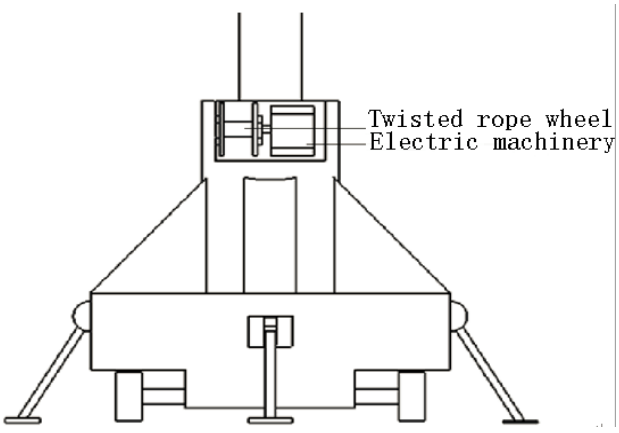

Fig.5 . Cleaning system winch drive device

As shown in Fig. 6, a fixed pulley is provided on the top and the side of the bracket for fixing the position of therope and reducing the friction between the rope and the bracket. The bracket's rod can rotate 360 degrees to adjust the direction of the rope. The height of the bracket can be reduced to accommodate Different PV panels.

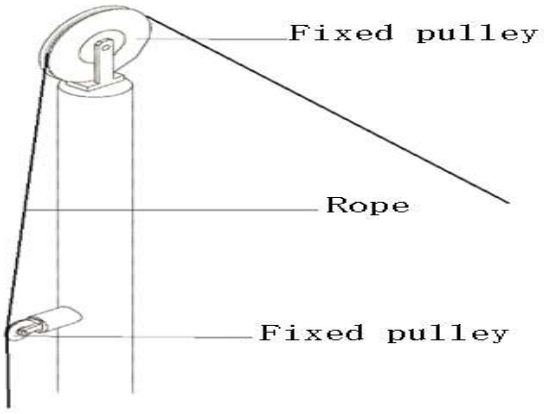

Fig.6 .Pulley unit of cleaning system

III. Snow melting drum based on resistance wire heating

In the northeast cold area due to environmental factors, and other impurities in ice covered on the surface of the solar panel, resulting in cleaning, the cleaning efficiency is low, slow, as shown in Figure 7 is a schematic diagram of the principle of the cleaning unit of this system, as shown in Figure 8, cleaning roller has a resistance wire heating function of the outer wall. The cleaning roller is composed of a plurality of resistance wires are connected in parallel, the resistance wire in the case of electricity generating heat to melt the ice, figure 9 is cleaning circuit resistance wires are arranged in parallel on the outer wall of the drum diagram, melting snow resistance wire heating roller based on improved cleaning efficiency and speed, to overcome the environmental factors of northeast Chinese other regions, to achieve a large area of mechanization.

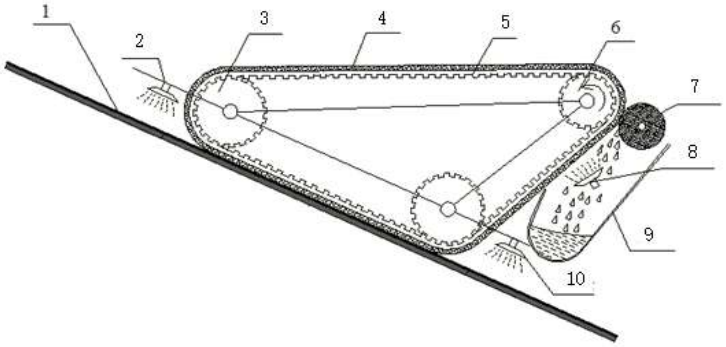

Fig.7.Schematic diagram of the principle of cleaning unit

1-Solar panels 2- First battery board cleaning nozzle 3- Cleaning roller 4- Rag
5- Synchrobelt 6- Drive roller 7- squeeze roll 8- Cleaning sprinkler
9- Water receiving box 10- Second battery board cleaning nozzle

Fig.8. Cleaning roller with resistance wire heating function

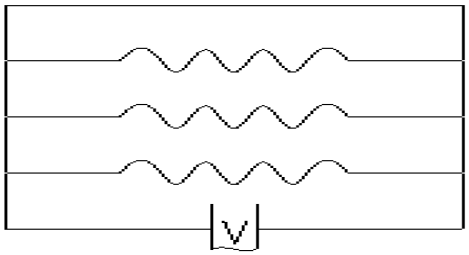

Fig.9.parallel arrangement of resistance wires

Kinematics analysis:

A rope traction mechanism consisting of 6 stents, each bracket extends a rope and is connected to 6 equilibrium points on the cleaning mechanism. The direction of the cleaning mechanism is traced by 6 ropes, and the power of walking is provided, so as to achieve the purpose of cleaning robot's Cross row cleaning[4-5].

Under a given trajectory, the moving platform is moved by the control of the winch input current to make the mobile platform move in the desired speed and direction. The parallel mechanism consists of at least n+1 cable to n degrees of freedom of the traction rope traction mechanism based on position analysis, velocity analysis and acceleration analysis, the optimal design of a traction rope 6 by force transmission of 5 degree of freedom parallel mechanism has good performance, large working space, properties of the 5 degree of freedom completely parallel mechanism and rope haulage force screw closed space, the necessary and sufficient conditions are given and proved in different traction rope root number pose belongs to wrench closed working space, to meet the analysis of geometric features of [6-7] vector closed structure matrix corresponding to the principle.

The posture of platform is known;i.e. $\mathrm{P}:\left(X_p, Y_p, Z_p, \varphi_p, \varphi_R, \varphi_Y\right)$, Seek the length of each rope: $\mathrm{L}i\ \left(i = 1,2,3\ldots,6\right)$, because the length of each rope to meet $\mathrm{L}_i^2 = \left\|P_i - B_i\right\|^2$, where 其中$P_i = \left(X_{pi}, Y_{pi}, Z_{pi}\right)$, $B_i = \left(X_{Bi}, Y_{Bi}, Z_{Bi}\right)$,If the pose of the moving platform is known, the coordinates of the connecting point on the moving platform in the fixed coordinate system satisfy:

$$\begin{bmatrix} X_{Pi} \\ Y_{Pi} \\ Z_{Pi} \end{bmatrix} = \begin{bmatrix} X_P \\ Y_P \\ Z_P \end{bmatrix} + T^T \begin{bmatrix} x_{Pi} \\ y_{Pi} \\ z_{Pi} \end{bmatrix} \quad (1)$$

Where

$$T = \begin{bmatrix} c_p c_p & c_R c_Y + s_R s_p s_Y & s_R s_Y - c_R c_p c_Y \\ -c_p s_y & c_R c_Y - s_R s_p s_Y & s_R c_Y + c_R s_p s_Y \\ s_p & -s_R c_p & c_R s_p \end{bmatrix}$$

$c_R = \cos\left(\varphi_R\right), c_P = \cos\left(\varphi_P\right), c_Y = \cos\left(\varphi_Y\right),$

$s_R = \mathrm{si\,n}\left(\varphi_R\right), s_P = \mathrm{si\,n}\left(\varphi_P\right), s_Y = \mathrm{si\,n}\left(\varphi_Y\right),$

The length of the root rope can be calculated by $I\,i\ \left(i = 1,2,3\ldots,6\right)$Thekinematic position of a rope pulling mechanism is the only one.

Based on vector closure principle, a simple calculation method of 6 rope traction six degree of freedom linkage mechanism for workspace is introduced. If the pose of the moving platform (with the point P as a standard) is described by ($x, y, z, \alpha, \beta, \gamma$), The basic steps are as follows:

1) set each ropes vector bit $\omega_i\ \left(6\times 1\right)\left(1 \le i \le 6\right)$,

Where $\omega_i = \begin{Bmatrix} \vec{f}_i \\ \vec{r}_i \times \vec{f}_i \end{Bmatrix} \vec{f}_i = \begin{Bmatrix} f_{ix} \\ f_{iy} \\ f_{iz} \end{Bmatrix} \left(f_{ix}^2 + f_{iy}^2 + fz = 1\right)$

$\vec{r}_i$ is the displacemen vector from the center of the moving platform to the fixed point of the i-th rope and $\begin{Bmatrix} r_{ix} \\ r_{iy} \\ r_{iz} \end{Bmatrix}$. moving platform,

2)Let $\omega\left(6\times 6\right) = [\omega_1, \omega_2, \ldots, \omega_6]$,introduce vector $r\left(6\times 1\right) = -W^1 w_6$,Then r for the i-th element is $\left(1 \le i \le 6\right)$.

3）Let $\left(1 \le i \le 6\right)$, seek the positions of all mobile platforms except for those condition.Then these locations of $\left(X_p, Y_p, Z_p\right)$ are parallel to the platform can be achieved.

4）With $\left(X_p, Y_p, Z_p\right)$ where All locationsThe collection is reachable location workspace, On this basis to find a collection of gestures of $\left(\varphi_R, \varphi_P, \varphi_Y\right)$,it is reachable location workspace.

IV. Acknowledgment

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V. Conclusion

1) The Solar Panel Cleaning System in Frozen Environment for Distributed Photovoltaic Generation is put forward. A drum cleaning system for distributed PV generation of heat and resistance wire in ice and snow environment is put forward, which can be applied to the solar photovoltaic group with multiple rows of buildings and dangerous areas in freezing weather.
2) 2)Based on positioning the cleaning cylinder by the parallel cable driving mechanism, the center of gravity can reduce the number of .cables. And the Swing movement can help cleaning the snowThe application of the system can help to realize the industrialization of the cleaning process of the solar panel.

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