ISSN: 2414-1895 DOI: 10.6919/ICJE.202208_8(8).0079

The Drone Combines a Compressed Air Solar Panel Cleaning Device

Zimo Bai[1], Lixin Sun[2], and Songlin Chen[3]

[1] School of Artificial Intelligence, North China University of Science and Technology, Tangshan 063000, China

[2] School of Science, North China University of Science and Technology, Tangshan 063000, China

[3] School of Materials Science and Engineering, North China University of Science and Technology, Tangshan 063000, China

Abstract

With the proposal of the national dual-carbon policy, solar cell power generation has gradually become a powerful "weapon" instead of fossil fuel combustion power generation. However, the solar panels used outdoors for a long time will be greatly reduced due to ash and other reasons, the solar panels located in the mountain areas are difficult to clean up and the power supply problems occur frequently, so this work uses unmanned aerial vehicles instead of cleaning vehicles, through automatic cruise and infrared monitoring systems, high-pressure water mist cleaning of large-area solar panels in mountain areas, and the use of high-pressure air compressors made of curtailment as energy, the clean solar panels are dried to achieve the purpose of preventing secondary dust.

Keywords

Clean; Drone; Compressed Air; Duck Curve; Hot Spot Effect.

1. Introduction

At present, the country is vigorously developing clean energy, and solar energy has been widely used[1]. After investigation, it was found that the accumulation of a large amount of dust will greatly reduce the power generation rate of solar panels, and due to irregularity in the arrangement angle of solar panels, cleaning has become a major problem. The existing waterless cleaning device is not very effective, and the device that uses water resources for cleaning has caused a waste of water resources to a certain extent. This work according to the UAV monitoring and spraying water mist combined with compressed air, so as to achieve the purpose of cleaning solar panels, this work first uses the water mist sprayed by the UAV combined with the water mist sprayed by the high-pressure nozzle to clean the large particles of dust and adsorb the tiny dust particles, and then uses the curtailment of the solar power station after the grid is connected, which is converted into compressed air under the action of the air compressor, so as to use the high-pressure high-speed air flow to impact the water stains with tiny dust particles. [2]The device solves the problem of cross-regional cleaning, and the use of water mist saves water resources and effectively avoids secondary pollution. Moreover, the effective use of curtailment, slowing down the slope of the duck curve, and improving the utilization rate of solar power generation.Section Headings. [3].

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2. System Design

The solar panel cleaning device consists of three parts: unmanned aerial vehicle system, air compressor system and high pressure spray system. [4]Electricity generated by solar energy cannot be integrated into the grid and is stored by air compressors for subsequent cleaning. The workflow of the whole system is divided into the following three steps.

The first step is to use the infrared thermal imaging function itself to detect the solar panel area, and if there is no hot spot, the next solar panel is detected; If there is a hot spot, it means that there is a high probability of debris and the solar panel needs to be cleaned.

The second step, cleaning, first uses the nozzle with the drone to spray water mist, and then the air compressor sprays high-pressure air to impact the water stains with tiny dust particles.

The third step is to use the infrared thermal imaging function to detect the solar panel area again, if there is no hot spot, the cleaning is completed, and the next solar panel is detected; [5] If there are still hot spots, it means that there is a high probability that the battery assembly is defective here, and the signal needs to be transmitted to the staff for further inspection.

3. System Composition

3.1 Unmanned Aerial Systems

3.1.1 Drone Fuselage Module

The model of the UAV used in this system is DJI S900 type six-rotor UAV, the structure is designed with V-type hexacopters, the motor wheelbase reaches 10.45cm, and the six shafts and center plates are cnc aviation aluminum foldable connectors, which is so that the aircraft can be folded and stored during transportation. The main body of the six-rotor UAV can be summarized as: fuselage center plate, shaft and tripod, which are selected for high-strength and lightweight carbon fiber materials.

Figure 1. Drone fuselage module

3.1.2 Motor Drive Module

Motor drive module is composed of motor, ESC, propeller, S900 six-rotor UAV using 4114pro model motor, the motor using a single strand winding stator winding, winding resistance is strong, the maximum power can be 500W, a single weight is only 158g. Each robotic arm is equipped with a 60A high-speed ESC, so that the motor can work with the folding paddle, so that the six-rotor UAV can fly or hover without pressure.

Figure 2. Assembly diagram of the motor drive module

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3.1.3 Flight Control Module

The core of the entire flight control system is the flight control module, which is responsible for collecting data from each sensor in each control cycle, and then according to the operation control law and data, by generating motor control instructions to control the attitude and flight trajectory of the UAV, in addition to the above functions, the flight control module is also responsible for the interaction of information with the ground station.

Use advanced industrialized precision calibration algorithms and temperature compensation algorithms. The main controller has a built-in 14-channel receiver based on DJI DESST technology, which can be used with remote controls from the Futaba FASST series and the DJI DESST series.

The flight controller of the system is equipped with two CAN bus interfaces that can work independently, which ensures that the system can have strong expansion performance. In addition, the flight controller has 4 output channels that can be independently configured, can be connected to the DSM2 model wireless satellite receiver, and optionally equipped with the D-BUS DJI Adapter module to support ordinary receivers, as shown in Figure 3.

Figure 3. DJI A2 Flight control

3.1.4 Sensor Module

The sensor module plays a perceptual role on the UAV, including altimeters, position sensors and attitude sensors, including various sensors are used to measure the height information, attitude information and position information of the UAV, etc., and then feedback to the flight control module to calculate the flight state of the UAV. The system uses the inertial measurement unit IMU sensor module mated to the DJI A2 flight controller. As shown in Figure 4, the inertial measurement unit integrates a triaxial angular velocity meter, a triaxial accelerometer and an altimeter, and the flight status of the UAV can be accurately obtained after calibration.

Figure 4. Sensor module

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3.1.5 GPS Module

The GPS module model used in this article is DJI's GPS-COMPASS PRO PLUS, which includes a compass GPS. The compass is used to collect information about the geomagnetic field and use GPS to achieve a drone fixed point. As shown in Figure 5, GPS-COMPASS PRO PLUS adopts a new generation of positioning acceptance chip, which enhances the filtering ability of gps receiving link, has super anti-interference ability and satellite signal capture ability, and the positioning effect is remarkable.

Figure 5. GPS module

3.1.6 Gimbal and Aerial Photography Mission Equipment

Gimbal is used to install and fix the aerial photography equipment on the UAV mechanism, the gimbal adjusts the aerial photography angle of the aerial photography equipment by receiving control instructions to ensure the smooth operation of the aerial photography task. The gimbal can generally be divided into electric and fixed, because the electric gimbal has a wider aerial photography range than the fixed gimbal, so the system adopts an electric gimbal.

Aerial photography mission equipment is fixed on the gimbal to shoot the mission target, such as high-definition digital cameras and thermal imaging cameras. According to the thermal spot characteristics of solar panels mentioned above, the aerial photography mission equipment of this department uses infrared thermal imaging cameras. Infrared thermal imaging camera, is the use of infrared detectors and optical imaging objectives to receive the infrared radiation energy distribution image of the measured target reflected on the photosensitive element of the infrared detector, so as to obtain the infrared thermal image of the measured target, the infrared image and the measured object, with DJI custom PTZ Zenmuse XT has a 360 ° panoramic photography function, and the angle accuracy can reach up to ±0.01 °, which is the best effect of the shooting picture.

Figure 6. Zenmuse XT

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3.2 Ground Station System

3.2.1 Ground Station Operation Module

The ground station operation module is used to remotely monitor and control the flight of unmanned aerial vehicles and complete aerial photography tasks, which is generally composed of ground station software, data transmission radio, computer and hand remote control. The system uses the DJI Data Link 3 universal remote control, although it is called a remote control, but the Data Link 3 itself is a small ground station system. As shown in Figure 6, the DJI Data Link 3 Universal Remote Controller is highly integrated with the data transmission station, and its small size does not affect its ability to remotely control a distance of three kilometers and display flight status data. With up to 20 hours of battery life, the DJI Data Link 3 Universal Remote Control maintains a stable and smooth wireless connection at 2.4GHz.

Figure 7. DJI Data Link 3 universal remote control

3.2.2 Ground Station Accuracy Calibration Module

The inspection personnel first conduct field investigation of the detection area, divide the area to be detected into multiple sub-areas according to the actual conditions, and determine the complete image acquisition route through the flight route and graphic acquisition route of each sub-area. Suppose, when there are 60 groups of solar panels in the area to be detected, divided into four rows, each row has ten groups of solar panels, at this time, each row can be used as a sub-area, a total of 6 sub-areas, the flight path of the first sub-region can be set from right to left, the flight path of the second sub-region is from left to right, the flight path of the third sub-region is from right to left, and the flight route of the fourth sub-region is from left to right, and the order of collection is the first sub-region, the second sub-region, The third sub-region and the fourth sub-region, then the complete flight path is determined. [6] According to the flight path to determine the relevant flight parameters, manually operate the six-rotor UAV take-off inspection, that is, through the remote control supported by the six-rotor UAV, control the image information collection route and flight altitude of the hexacopter UAV. When the six-rotor UAV begins to patrol, the ground station sends instructions through the remote control to adjust the PTZ angle, and the six-rotor UAV gimbal equipped with an infrared thermal imaging camera begins to collect infrared video from the solar panel, and transmits the video information directly to the computer screen, which can facilitate the retention of data.

3.2.3 Air Compressor and Power Curtailment Utilization Technology Module

(1) The air compressor sucks in the air, filters through the air filter, and allows the clean air to enter the inside of the host; The solvent inside the two rotors changes through the meshing motion, at which point the cavity begins to continuously spew out oil, lubricate and cool the screw, which is obtained by mixing the required oil and gas; The oil-gas mixture after the boost and heating is entered into the oil-gas separator tank through the exhaust check valve; Most of the oil in the main chamber mixture is separated from the compressed air in the oil-gas separator, and then cooled back into the main engine for recycling; When the minimum pressure of the air in the oil and gas separator is reached,

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the minimum pressure valve is opened, the high-temperature compressed air enters the aftercooler, and the temperature of the compressed air drops, at which time the compressed air is obtained.

(2) Wind power generation and photovoltaic power generation are called waste electricity due to low utilization rate, which is looked down upon, and we use these "waste electricity" for use in the system to reduce the consumption of the system. The output of new energy power generation is volatile, random and intermittent, and after large-scale new energy power generation is connected to the power grid, it will have a certain impact on the peak regulation, reactive voltage and transient stability of the power grid. At the same time, due to the uncertainty and anti-peak regulation of new energy (wind power and photovoltaic power generation) power generation output, large-scale new energy is required to leave more backup power sources and peak shaving power sources in the power system after being connected to the grid. Considering the cost and technical difficulty of installing backup power supplies and peak shaving power related devices, the use of existing air compressors to convert electrical energy into compressed air storage is obviously a better choice. Not only can the stored air be cleaned of dust by laying air ducts and nozzles to ensure power generation, but excess compressed air can also be used to generate electricity.

3.3 High Pressure Nozzle System

High-pressure nozzles are mainly used in the field of cleaning and descaling, and are designed according to water jet technology to effectively meet customer needs. The size of the nozzle area has a very important role in the high-pressure cleaner, if the nozzle nozzle area is large, it will make the average kinetic energy of the high-pressure cleaner spray greatly reduced, in some systems will also cause the gauge pressure can not directly reflect the actual change of the spray kinetic energy at the nozzle. If the nozzle area is small, it will produce serious reflux, which will also lead to a decrease in the spray kinetic energy of the high-pressure cleaner. [7]Therefore, in order to give full play to the cleaning effect of the high-pressure cleaner, it is necessary to calculate the matching high-pressure nozzle nozzle area.

The high-pressure nozzle in this device is installed on the solar panel, so that the water flow becomes a high-pressure water mist to reach the water mist sprayed by the UAV, cleaning the large particles of dust on the solar panel and adsorbing fine dust.

4. Conclusion

At the current stage of solar resource research and development, the cleaning problem of solar panels needs to be effectively solved. In the process of use, the system greatly reduces the requirements for the terrain and terrain of the solar panels, the number of scales, the preparation of funds and other aspects, and to a certain extent, solves the problem that the power generation of solar panels is "duck curve". In line with the national concept of energy conservation and emission reduction and sustainable development, it has broad application prospects.

References

[1] China Photovoltaic Industry Association, CCID Think Tank Integrated Circuit. "Development roadmap of China's photovoltaic industry(2020) " [R]. 2021.

[2] China Photovoltaic Industry Association, CCID Think Tank Integrated Circuit. Annual report of China's photovoltaic industry from 2019 to 2020[R]. 2020.

[3] JIANG H, LU L, SUN K. Experimental investigation of theimpact of airborne dust deposition on the performance of so lar photovoltaic(PV)modules[J]. Atmospheric Environment, 2011, 45(25): 4299-4304.

[4] Bao Guanjun. Review of research on photovoltaic panel dust accumulation and dust removal cleaning technology [J]. Mechanical and Electrical Engineering, 2013, 30 (8): 909-913.3.

[5] Fan Difei, Dong Binghai, Wang Shimin, Zhao Li, Wan Li, Xu Zuxun, Wu Yadan. Research progress of solar panel surface self-cleaning technology [J]. Materials Review. 2015 (19).

[6] California ISO. What the duck curve tells us about managing a green grid[R]. California ISO,2015.