

# *Design and Manufacture of Hand Held Photovoltaic Power Generation Equipment Cleaner*

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**Abstract:** With the development of science and technology and the worsening of human environment, the deepening of human environmental awareness makes photovoltaic power generation technology, as one of the main green energy sources, more and more widely used. At the same time, the surface of photovoltaic panels is polluted by sand and dust during use, which affects the efficiency of photovoltaic power generation. Therefore, the cleaning of photovoltaic panels is very important. However, the existing cleaning equipment, such as high-pressure water gun and scraper, has low working efficiency and unsatisfactory cleaning effect; In this context, we designed and developed a portable PV power panel cleaner with compact structure, light weight, durability and easy operation according to the needs of relevant enterprises. Field experiments on design samples show that the cleaner meets the design requirements and meets the market needs.

## **1. Introduction**

With the development of science and technology, the worsening of the environment and the deepening of the awareness of environmental protection, photovoltaic power generation technology, as one of the main green energy sources, is more and more widely used in various fields of electricity. During the use of photovoltaic power generation, the photovoltaic power generation panel is polluted by sand and other substances, which will seriously affect the efficiency of photovoltaic power generation. On the one hand, the surface pollution of photovoltaic modules has a significant impact on their power generation efficiency. The main impact principle is that the surface pollution of photovoltaic panels affects the light transmittance, and then affects the radiation received by the module surface. In addition, dust, as a material with low thermal conductivity, is deposited on the surface of the photovoltaic panel to block the heat transfer of the panel, which is likely to prevent the heat of the photovoltaic panel from being released. The temperature of the photovoltaic panel is getting higher and higher, affecting the efficiency of photovoltaic power generation. At the same time, there may be a risk of spontaneous combustion caused by local overheating of the panel, namely, "hot spot effect". The temperature effect of ash deposition directly affects the module temperature and thus affects the power output of photovoltaic modules. When the dirt on the surface of the module is partial shelter such as leaves, soil, bird droppings, etc., its principle of action is more reflected in the impact of the hot spot effect. On the other hand, substances such as ash deposited on the photovoltaic power generation board have corrosive effects.

The corrosion of acid or alkaline substances on the glass cover plate increases the energy of reflected light and decreases the energy of refracted light, which weakens the light intensity incident on the photovoltaic power generation board, leading to the weakening of the photoelectric effect and the reduction of power generation. And its damage to the solar panel is permanently irreparable, which shortens the service life of the equipment. The above analysis shows that regular cleaning and maintenance of photovoltaic power generation equipment is very necessary, while the existing cleaning equipment, such as high-pressure water gun and scraper, is inefficient and the cleaning effect is not ideal; In this context, we designed and developed a portable photovoltaic panel cleaner with compact structure, light weight, durability and easy operation to meet the needs of relevant enterprises. Field experiments on design samples show that the cleaner meets the design requirements safely and reliably and meets the market needs[1-3].

## **2. Overall design scheme of handheld photovoltaic power generation equipment cleaner**

### **2.1 Functional design analysis:**

In the past, PV power generation panels were generally cleaned with high-pressure water gun or with glass scraper dipped in water. These cleaning methods are not easy to clean and maintain thoroughly, and the efficiency is low and water waste is serious; For this reason, we have explored a more efficient and energy saving cleaning method in practice: combining water spraying and automatic brushing, cleaning while washing can effectively remove the dirt on the surface of the photovoltaic power panel, so a hand-held cleaner is designed to complete the cleaning function.

### **2.2 Structural design analysis**

The hand-held PV power panel cleaner (hereinafter referred to as the cleaner) consists of four parts, namely, the cleaning head, the long handle, the 12V DC power supply and the water supply tank.

**Cleaning head:** in order to complete the cleaning and spraying functions, the cleaning head is equipped with a roller type soft bristle brush that can rotate at a low speed and an adjustable spraying device. For the sake of compact structure and overall weight, the portable drive motor is installed in the roller soft brush, and the power is transmitted to the roller brush through the connecting piece to make it rotate to complete the cleaning work. At the same time, the adjustable nozzle installed in the middle of the bottom of the cleaning head, under the action of the electric water pump, sprays water to the photovoltaic power generation panel through the high-pressure water pipe to complete the cleaning work.

**Long handle:** the handle is a tubular structure, 2m long, 30mm diameter stainless steel thin-walled tube, one end of which is fixedly connected with the cleaning head through a connector. Its function is that the operator can hold it in hand and control the cleaning process through the power switch installed at the lower hand of the handle. When it is turned on, the electric roller brush rotates and the nozzle sprays water through the high-pressure water pump. When it is turned off, the roller brush stops rotating the nozzle and stops spraying water. The wire through the other end of the handle is connected with the portable charging power supply, and the power control wire is connected with the water pump; The high-pressure water pipe is connected with the water pump in the water storage tank.

## 2.3 Operating principle of washer

The low-speed motor installed inside the roller soft bristle brush transmits power to the transmission shaft through the coupling, and then the end cover and lock nut transmit power to the roller soft bristle brush for rotation. The cleaning head can complete the cleaning task under the pressure generated by the vertical component force of the photovoltaic power generation board with its own weight and the rotating force of the brush; The friction force of the rolling brush can remove the dirt on the photovoltaic power generation board. At the same time, the adjustable sprinkler sprays water to the photovoltaic power generation panel at a suitable angle and a certain pressure for cleaning[4-6].

## 2.4 Washer design requirements

The overall size of the cleaning head of the handheld photovoltaic power generation equipment cleaner shall be as small as possible, the weight shall be as light as possible, the operation shall be flexible and convenient, the working reliability shall be high, and it shall be able to work in harsh environments and be easy to operate without failure without affecting its cleaning effect and other functions. The structural design shall be reasonable and compact, and light materials shall be selected as far as possible while ensuring the strength of each component and the overall strength.

## 3. Design scheme of washer parts

### 3.1 Structural design of cleaning head components

The structural characteristics of the cleaning head composed of related parts are: reasonable and compact structure, light and convenient, reliable work, and high efficiency. When the cleaning head is working, the low-speed motor installed in the drum soft bristle brush rotates at the speed of 60 revolutions per minute. The power is transmitted to the transmission shaft through the coupling, and then the power is transmitted to the drum soft bristle brush by the end cover and lock nut on the transmission shaft for rotation. The motor shell is fixedly connected with the cleaning head bracket through a connector. The hole with a diameter of 25mm at the middle end of the bracket at the bottom of the cleaning head is used to fix and install the long handle, power cord and water spray pipe. There is a rectangular through-hole in the transverse distance direction between the middle of the support bottom plate and the long handle connector to install the spray nozzle. The test proves that the cleaning effect of the spray nozzle installed at this position is the best. The nozzle is a special nozzle for Zhonghua car. The spray direction of the nozzle can be manually adjusted. During the test run of formed products, the spray angle can be adjusted according to the placement position and specific conditions of the equipment to be cleaned.

### 3.2 Design of important parts of cleaning head: select the following important parts to describe the manufacturing process in detail

#### 3.2.1 Support plate parts with positioning holes

(1) The role of the support plate with positioning hole in the cleaning head: the support plate with positioning hole plays the role of supporting the positioning fixed shaft at one side of the cleaning head, and it is the connecting piece connecting the fixed shaft and the bottom plate.

(2) Parts processing process and precautions: taking into account the requirements of both strength and overall weight, the parts are made of 5mm thick aluminum alloy plates as raw

materials. First, the aluminum alloy plate shall be cut into blanks with a shearing machine according to the design size, and then the blank shall be marked according to the size marked on the drawing. The bottom surface shall be processed first, and other forming surfaces and holes shall be processed based on this surface. It is worth noting that the accuracy of the bottom surface as the datum surface shall be guaranteed during processing, especially the processing of the positioning hole shall meet the tolerance requirements marked on the drawing.

### **3.2.2 Base plate parts**

(1) The function of the base plate parts: it is the basic installation part of the entire cleaning head. All parts of the cleaning head are fixed on the base plate through various connecting pieces, and the long handle is fixed on the base plate through the connecting sleeve. In addition, the spray nozzle is also fixed on the base plate.

(2) Parts processing process and precautions: taking into account the requirements of both strength and overall weight, the parts are made of 5mm thick aluminum alloy plates as raw materials. First, the aluminum alloy plate shall be cut into blanks with a shearing machine according to the design size, and then the blank shall be marked according to the size marked on the drawing, and then processed according to the line. First, the datum plane shall be processed, and then the remaining faces shall be processed, and each hole shall be processed according to the size of the drawing. Note: There are tolerance requirements for the middle mounting hole, and the size of the nozzle mounting hole should be repaired in strict accordance with the drawing size, otherwise there will be problems in the installation and fixation of the nozzle.

### **3.2.3 Motor mounting plate parts**

(1) The function of the motor mounting plate is to fix the motor housing with fixed shaft parts through bolts.

(2) Machining of motor mounting plate and precautions: aluminum alloy materials shall be used for machining. First, use a scribe, ruler, and angle ruler to mark the center and four bolt hole positions on the aluminum alloy plate, and then drill the center hole and the other four holes on the drilling machine. Note: the center hole shall be drilled with a diameter of 10mm first, and then use special bolts to pass through the center hole and install it on the lathe to process the outer circle, and then install the clamp to process the inner hole according to the size of the outer circle.

### **3.2.4 Fixed shaft parts**

(1) The function of fixing the shaft is to fix the motor shell through bolts, support the roller soft brush and seal the motor through bearings, fix them on the support frame, and pass through and fix wires.

(2) Processing of fixed shaft and precautions: due to the need for matching and hardness requirements, the material used for this part is 45 # steel, which is an important part of the cleaning head. After turning, the workpiece is formed after heat treatment. Pay attention to the tolerance requirements.

### **3.2.5 The function of the connector: to connect the support plate to the base plate**

Processing and material selection of connecting parts: aluminum alloy angle aluminum material is selected, which has good strength and light weight. After sawing and cutting according to the drawing size, use a file to level the leading edges and corners, and then draw lines to position and process the fixing bolt holes. It is worth noting that there are two connecting plate parts, which can

be exchanged after processing without affecting the installation.

### 3.2.6 Plug parts

(1) The role of the screw plug parts in the overall structure is to fix the fixed shaft on the positioning support plate to limit its radial and axial displacement.

(2) Material selection and processing of screw plug: in order to reduce the overall weight, the screw plug is made of aluminum alloy material by turning. The threaded connection of M14 has tolerance requirements. See the figure for details. The through holes of four fixing screws are evenly arranged.

### 3.2.7 Threaded hole end cover

(1) The role of the threaded hole end cover in the mechanism: supporting the fixed roller soft bristle brush and the shaft.

(2) Material selection and processing of threaded hole end cover: aluminum alloy bar shall be selected for turning according to requirements, with special emphasis on the tolerance requirements for the outer circle with a diameter of 61mm, and the accuracy requirements for M12 internal thread.

### 3.2.8 Sleeve parts

(1) The role of sleeve parts in the mechanism: it plays a positioning role between the outer ring of the bearing and the oil seal to limit the axial movement of the bearing.

(2) Material selection and processing of sleeve parts: considering the whole and its role, aluminum alloy bars are selected for lathe turning. It must be noted that the outer circle with a diameter of 37mm has tolerance requirements.

### 3.2.9 Small end cover parts

(1) The role of small end cover parts in the mechanism: used to limit the axial movement of oil seal and support the fixed shaft.

(2) Material selection and processing of small end cover parts: it is made of aluminum alloy bar by lathe turning. Pay attention to the tolerance requirements for the excircle boss with a diameter of 45mm.

### 3.2.10 Support plate parts

(1) The role of the support plate parts in the cleaning head: the support plate plays the role of fixing the bearing seat on one side of the cleaning head and connecting the bottom plate through its own fixation.

(2) Parts processing process and precautions: taking into account the requirements of both strength and overall weight, the parts are made of 5mm thick aluminum alloy plates as raw materials. First, the aluminum alloy plate shall be cut into blanks with a shearing machine according to the design size, and then the blank shall be marked according to the size marked on the drawing. The bottom surface shall be processed first, and other forming surfaces and holes shall be processed based on this surface. It is worth noting that the accuracy of the bottom surface as the reference surface shall be guaranteed during processing.

### 3.2.11 Shaft parts

(1) The role of shaft parts in the mechanism: the motor power is transmitted to the end cover of the threaded hole through the coupling to drive the roller soft brush to rotate synchronously and to fix the support.

(2) Processing of fixed shaft and matters needing attention: due to the need for matching and hardness requirements, in order to increase the strength and the material used for this part is one of the important parts of the cleaning head, 45 # steel is selected. After turning and heat treatment of the workpiece, attention should be paid to the accuracy requirements of M12 external thread, and the dimensional tolerance and geometric tolerance requirements of the diameter external circle with a diameter of 10mm at both ends.

### 3.2.12 Bearing hole end cover parts

(1) The role of bearing seat hole end cover parts: the role of fixing the fixed shaft through bearing support and fixing the sleeve, oil seal, threaded hole end cover and roller soft bristle brush together.

(2) Material selection and processing of bearing seat hole end cover parts: aluminum alloy bars are selected for lathe turning. Note: The outer boss with a diameter of 61mm has tolerance requirements, and the inner holes with a diameter of 37 and 45 also have tolerance requirements.

The above is the design scheme of each main part of the cleaning head.

## 4. Matters needing attention

The installation of the spray nozzle shall be adjusted according to the actual working environment. The test proves that the spray nozzle is installed in the middle of the bottom plate, and the cleaning effect is best when the spray direction is sprayed between 1cm and 2cm above the contact line between the roller brush and the cleaning surface. The nozzle is a special nozzle for Zhonghua car. The spray direction of the nozzle can be manually adjusted. During the test run of formed products, the spray angle can be adjusted according to the placement position and specific conditions of the equipment to be cleaned. Note: There are tolerance requirements for the middle mounting hole, and the size of the nozzle mounting hole should be repaired in strict accordance with the drawing size, otherwise there will be problems in the installation and fixation of the nozzle.

## 5. Conclusion

Trial produce a complete set of parts according to the designed parts drawings. After assembly according to the designed assembly drawings, test run the finished products according to the actual requirements. After testing and debugging, the roller soft bristle brush of the cleaner has better cleaning effect under the condition of sequential cleaning. The test shows that the handheld photovoltaic power generation equipment cleaner designed by us meets the design requirements and meets the requirements of the user.

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