Design of Robot System for Cleaning Glass Curtain Wall

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Abstract—The glass curtain wall has good heat preservation and moisture-proof performance and beautiful appearance. It is used as exterior wall decoration in high-rise buildings, its cleaning work is difficult and dangerous. In this paper, the design research of the glass curtain wall cleaning robot is carried out, and a rail-type glass curtain wall cleaning robot is designed, which is mainly composed of a detachable rail and a robot, and is controlled by a 51 microcomputer. The three-dimensional design of the cleaning robot was performed using NX software, and a model prototype was produced. This robot is light in weight and flexible in control. It is suitable for cleaning operations of large glass curtain walls and can reduce the risk factor and labor intensity of cleaning operations.

1. Introduction

With the development of urbanization, there are more and more high-rise buildings in major cities across the country. Due to the characteristics of good heat and moisture resistance and beautiful appearance of glass curtain walls, it is widely used in high-rise buildings in modern cities and has become a beautiful scenery in modern cities. In order to maintain the aesthetics of the building, the glass curtain wall must be cleaned regularly. In recent years, the governments of first- and second-tier cities have made clear regulations on the cleaning of high-rise facades in the form of government orders: once a year in Beijing, 2-4 times in Shanghai, once a year in Shenzhen and so on. Correspondingly, the traditional manual hanging basket cleaning method has high cost, low efficiency, high labor intensity, and high risk factor. Countless casualties occur every year due to falling from the sky, and they are no longer suitable for these huge amounts of cleaning work[1-3]. Taking the cleaning of the glass curtain wall of the CCTV building in 2015 as an example, the entire "big pants" was cleaned for more than 40 days before and after it cost nearly ¥500,000. However, a few days later, a yellow sand made it back to before liberation. They had to re-exploit laboriously to clean again. It has become an inevitable trend for the development of the industry to carry out research on glass curtain wall cleaning robot.

Most of the glass curtain wall cleaning robots currently on the market and under development are negative pressure suction cups[4]. In the face of such a huge glass curtain wall cleaning market in China, robot cleaning undoubtedly has a huge development space and profit space, but we can also see that
there are so many customers in the market, each customer has its own different needs, so the robot must meet different working environment to work. It is still a difficult problem for glass curtain wall cleaning robots to occupy the vast cleaning market. First of all, the robot technology needs to be further improved. In addition, as a new cleaning operation method, it will make people gradually accept, and then the traditional cleaning form will be eliminated.

The glass curtain wall cleaning robot helps to reduce the incidence of safety accidents and improve work efficiency, and has important significance and a broad application market.

2. Overall design of glass curtain wall cleaning robot

The glass curtain wall cleaning robot must have three functions, namely, moving function, adsorption function, and cleaning function[5]. The moving function and the adsorption function of this design are realized by the rack rail design. The rack rail is adsorbed on the connecting member of the glass curtain wall by strong magnetism, and it can be removed after the cleaning work is completed. The glass curtain wall cleaning robot realizes the movement of the robot through the cooperation of gears. The monitoring equipment and feedback system monitor the running and cleaning status of the robot in real time, and control and monitor the robot equipment through the remote wireless control equipment. The robot is divided into two working modes, namely, the autonomous operation mode, which can automatically run the cleaning without the need for operators to operate at all times; the manual operation mode can also intervene in the operation state of the robot to avoid cleaning due to the autonomous operation mode incomplete situation. The robot has two working modes, that is, the autonomous operation mode, which can automatically run the cleaning without the need for the operator to operate at all times; the manual operation mode can also intervene in the operation state of the robot to avoid incomplete cleaning due to the autonomous operation mode case.

The overall technical route of the glass curtain wall cleaning robot is shown in Figure 1, and the overall structure and part of the track of the glass curtain wall cleaning robot are shown in Figure 2.

3. Design of various parts of the glass curtain wall cleaning robot

3.1. Mobile walking

The two ends of the track are equipped with strong magnetic chucks matched with the glass curtain wall connectors. During the installation, only the strong magnetic chucks and the glass curtain wall connectors can be adsorbed together to achieve the construction of the track, which is simple and fast.

The mobile system includes a rack track of modulus 1, a walking gear, a worm gear motor, and a circuit control part. The rail makes the glass curtain wall cleaning robot adsorb on the curtain wall. Compared with the common vacuum suction cup adsorption, the rail type adsorption can make the robot run more stable, the cleaning effect is more obvious, and because the vacuum negative pressure pump is omitted, the Cleaning robots are more energy-efficient, which in turn makes cleaning costs cheaper.

The walking gear is connected to the worm gear motor and moves along with the rack rail. The worm gear motor itself has good self-locking performance, so there is no need to consider the motor self-locking of the design circuit part, while simplifying the circuit design, it also reduces the overall weight of the curtain wall cleaning robot.

3.2. Cleaning system

The high-pressure water jet is used for cleaning, and the high-speed and high-pressure water jet is used to destroy and remove the dirt, and then play a cleaning role. This cleaning method has the following characteristics:

High cleaning efficiency. Due to the composite breaking effects of water jet erosion, wedge splitting, shearing, grinding, etc., the scale can be quickly broken off, and the cleaning speed is several to ten times faster than the traditional simple mechanical and manual methods. At the same time, the parts
cleaned with high-pressure water jets do not need to be cleaned twice; and after chemical cleaning, the surface chemicals need to be cleaned with clean water.

Figure 1 The overall technical route of the glass curtain wall cleaning robot

1. Connecting components; 2. Strong magnetic magnetic suction; 3. High pressure water pump; 4. Pressure control valve; 5. PVC water pipe; 6. Slider; 7. Cleaning nozzle; 8. Control electric box; 9. Steering engine; 10. Camera; 11. Traveling gear; 12. Worm gear motor; 13. Gear rack guide

Figure 2. Main structure of glass curtain wall cleaning robot
No environmental pollution. Because high-pressure water jet cleaning uses clean water as the medium, water jet cleaning does not generate a lot of dust like sandblasting or simple mechanical cleaning, polluting the atmospheric environment and harming human health. It is also not like some chemical cleaning, which produces a lot of waste liquid to pollute the river, soil and water quality. The water jet with clear water as the medium is odorless, tasteless and non-toxic. After the spray jet is atomized, it can also reduce the air dust concentration in the work area and below the national safety standards, so it will not cause any pollution. In addition, the recovery of high-pressure water jet cleaning fluid is also relatively easy to achieve technically.

Energy saving, water saving and low cleaning cost. The medium used for high-pressure water jets is tap water, which is easy to source and ubiquitous. In the cleaning process, due to the powerful energy, it can be cleaned without adding any filler and detergent, so the cleaning cost is low.

3.3. Remote control and monitoring system
The control box is shown in Figure 3, and the cleaning robot is controlled by an industrial-grade RXC68 wireless remote control system, as shown in Figure 4, which can achieve a remote control range of 3000 meters from a long distance, and has strong anti-interference ability. Cooperating with the program development of 51 microcomputer, the remote control operation is more intelligent. It is divided into two modes: automatic operation mode, which can realize the operation and stop of the curtain wall cleaning robot with only one key control; artificial operation mode, which can manually operate the glass curtain wall cleaning Robot operation, stop and cleaning.

Figure 3 Schematic diagram of the control box
1. Display; 2. Electric quantity display; 3. Switch button; 4. Operation button; 5. Control antenna; 6. Emergency stop switch; 7. Operating the rocker

Figure 4 Front (left) and reverse (right) photos of the RXC68 wireless remote control module
At the same time, the control box is also equipped with 5.8G image transmission equipment, as shown in Figure 5, in order to achieve real-time monitoring of the running status and cleaning status of the glass curtain wall cleaning robot.

![5.8G video transmission equipment](image)

If it is monitored that the area is not thoroughly cleaned, it can be switched to human operation mode, and the glass curtain wall cleaning robot can be operated for secondary cleaning. The operation of the operator is more convenient and fast, and the appropriate operation position can be arbitrarily selected to operate the curtain wall cleaning robot.

### 3.4. Security System

In order to prevent the danger of falling objects at high altitude, the curtain wall cleaning robot is designed to be connected to the cable retracting device at the top of the building through a cable. Once the curtain wall cleaning robot has an accident, the cable can be lifted at the first time. While safe and effective cleaning, it can also guarantee the safety of people's lives and property.

### 4. Conclusion

According to the needs of high-rise glass curtain wall cleaning, this paper designs a rail type glass curtain wall cleaning robot system, including the overall design of cleaning robot, the mechanical structure of each part, the design of control hardware, etc. The track of cleaning robot adopts modular design, which is connected with glass curtain wall by using strong magnetic suction cup; the mobile system includes a rack track of modulus 1, a walking gear, a worm gear motor and a circuit control part; the cleaning system adopts high-pressure water jet cleaning technology; the core of the control system is 51 microcomputer, RXC68 wireless remote control system and 5.8G wireless image transmission system are used to realize remote control and real-time monitoring. The safety rope of the system is designed.

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