

Research and Discussion on Machine Cleaning Method on Glass Wall Curtain

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Abstract: With the rapid development of science and technology and the cross penetration and integration of various disciplines, the glass curtain wall cleaning robot has also developed rapidly, becoming a high-tech industry in the field of service robots and a key research topic in recent years and the future. This paper summarizes the types of glass curtain wall cleaning robots and the research status of the applied technology from the aspects of adsorption mode, moving mechanism, cleaning mechanism and modern intelligent technology. At present, there is still a certain gap between the glass curtain wall cleaning robot and the goal that people are satisfied with. Finally, some suggestions are put forward for the future development trend of glass curtain wall cleaning robot.

Keywords: Glass cleaning, Mobile mechanism, Glass screen wall, Cleaning function.

1. Introduction

With the development of modernization and the updating of the scientific and technological level, the continuous growth of the population has led to the increasingly tense urban housing, so there are more and more high-rise buildings[1]. According to the data, 90 million square meters of new glass curtain walls are built every year, so the cleaning market is huge and high cleaning costs can be obtained from it. With the development of mechanization and automation in all aspects of our country, people are eager to replace the traditional "Spider Man" with a new cleaning robot to clean the glass curtain wall and free their hands. High rise glass curtain wall cleaning robot is a new modern service industry based on wall climbing robot integrated cleaning technology and modern intelligent sensor control technology[2]. Intelligent mechanized cleaning robot has the characteristics of high speed, high safety and low cost compared with manual cleaning. In general, whether domestic or foreign glass curtain wall cleaning robots, there are still many shortcomings due to the working environment, stress state and other conditions. Therefore, there is still a lot of room for development in the field of glass curtain wall cleaning robots in the future[3].

2. Research Progress

The high-rise glass curtain wall cleaning robot can move

freely on the high-rise glass curtain wall and complete certain functions. It needs to have two basic capabilities: adsorption mode and moving mechanism[4]. The adsorption technology can generally be divided into vacuum suction disk adsorption, magnetic adsorption and thrust adsorption, as well as the adsorption methods such as glue adsorption, gecko like foot dry adsorption and snail like wet adsorption in recent years.

2.1. Adsorption Mode of Glass Curtain Wall

The high-rise glass curtain wall cleaning robot needs to work in a steep or even vertical environment. The first problem to be solved is to overcome its own gravity, achieve its fixation on the working surface, and ensure that it does not fall off during the movement. The adsorption method plays a vital role.

2.2. Vacuum Suction Cup

The vacuum suction cup adsorption technology can be divided into single suction cup and multi suction cup adsorption. The comparative analysis of the two negative pressure adsorption technologies is shown in Table 1. The suction cup robot suction device is generally composed of vacuum generator, suction cup and sealing device. The vacuum generator works to form a vacuum state in the negative pressure chamber so that the suction cup is firmly adsorbed on the glass curtain wall.

Table 1. Comparison and analysis of two vacuum chuck adsorption technologies

Vacuum chuck adsorption	Single suction cup adsorption	Multi sucker adsorption
Damage to glass surface	commonly	Small
Operation speed	slow	fast
Safety performance	difference	good
Wall adaptability	low	high

Most of the glass curtain walls have obstacles such as adhesive strips and joints. During the movement of the glass curtain wall cleaning robot, the suction cups adsorbed on these obstacles often lose their adsorption force due to air

leakage. The single suction cup mainly relies on the device to maintain good sealing to maintain its vacuum. When it crosses these obstacles, it will lead to the failure of the adsorption connection. The multiple suction cups will

compensate for the failure of the adsorption connection caused by the obstacles to a certain extent. Therefore, in the current design, most of the research focuses on the multi suction cup adsorption mode.

The multi suction cup window cleaning robot developed by literature[5] consists of 12 suction cups and 12 vacuum generators. In the design process, in order to reduce the axial force of the suction cups and reduce the impact of obstacles, the suction cups are divided into three groups and arranged longitudinally. When the robot works, when the longitudinal cylinder suction cup group completely contacts the working surface and reaches the adsorption state, the corresponding electromagnetic valve is opened, the vacuum generator works to generate vacuum, and the suction cup is adsorbed on the working surface. On the contrary, as the robot advances, when the suction cup is about to leave the plane, the corresponding solenoid valve is closed, and the suction force of the suction cup gradually drops to zero, leaving the glass surface.

literature[6] A portable automatic window cleaning robot jointly designed and developed by sisoyo of Swinburne University in Malaysia. The robot is a 37 × 18cm rectangular device weighs about 3.5kg. The adsorption device has 8 suction cups, each in a group of 4. It can be operated in automatic and manual modes. It drives two groups of suction cups by releasing gas alternately. At the same time, under the joint action of rotating brake, belt and pulley system, it can propel the robot body in a pre programmed swing mode on the 2D plane of the glass curtain wall. The cleaning work is completed by a pair of sponges attached on both sides, and a group of optical sensors are used to detect the window frame. The robot is light in weight, small in size and cheap in price. The portable automatic window cleaning robot is shown in Figure 1.

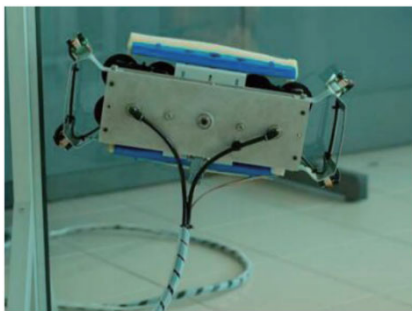


Figure 1. Portable automatic window cleaning robot

3. Thrust Adsorption Technology

A glass wall cleaning robot based on low-noise centrifugal fan adsorption system was developed by literature[7]. According to Bernoulli's principle, the robot uses a motor to drive a centrifugal fan to rotate at high speed. The air in the negative pressure chamber is discharged through the skirt of the negative pressure chamber, so that an instantaneous vacuum state is formed in the negative pressure chamber. By analyzing the frequency of rotating noise and eddy current noise, the number of rotations of the centrifugal fan is reduced to reduce the noise of the fan while ensuring that the robot is safely adsorbed on the glass; At the same time, the contact stress of the moving wheel is analyzed

The glass curtain wall cleaning robot based on syringe adsorption was jointly developed by literature[8]. The robot adsorption device is composed of a vacuum suction cup, a rubber tube, a 20ml syringe, a 1mm building string and a 12V

decelerating DC motor. In order to make the syringe tail move to the same position every time, a mechanical switch K1 is set at the position of the maximum movement of the syringe tail. When the syringe tail touches K1, the motor stops rotating. The structure of the thrust part of the glass curtain wall cleaning robot adsorbed by the syringe is shown in Fig. 2. After many tests, the adsorption success rate under static, low-speed and medium speed conditions is close to 100%, and the moving adsorption rate at high-speed is close to 95%.

3.1. Leg and Foot Movement Technology

The appearance of legged mobile technology has greatly improved the obstacle surmounting ability of glass curtain wall cleaning robot[9]. It is the main direction of the research on the mobile mechanism of glass curtain wall cleaning robot at present. There are two legs, four legs, six legs and even 22 legs. With the increase of the number of feet, the obstacle surmounting ability is improved to a certain extent, but the structure is complex, the control difficulty is increased, and the manufacturing cost is high.

A quadruped wall climbing robot has been developed by naver O and others at Carnegie Mellon University. The robot uses bionic technology. Its four legs are equipped with a new peeling mechanism suction cup with elastomer rubber pads. Its toes can be retracted and turned out. Each leg is driven by the steering gear. The tail is equipped with an active tail wing, which on the one hand plays the role of turning and stable climbing of irregular glass curtain walls, and on the other hand plays the role of scraping, eliminating the water marks left by the suction cup. The movement process is similar to the climbing gait of geckos. The experiment shows that the machine can crawl on an 85° slope, but it is not suitable for large-scale and long-time operation due to its simple mechanical structure and small load-bearing capacity. literature[10] climbing cleaning robot for cleaning glass curtain walls of high-rise buildings. The robot is composed of 1 main body and 6 symmetrical mechanical legs. The robot is simple in structure, with 18 rotating joints driven by the steering gear in the overall structure. It can move flexibly, and can realize straight-line triangular gait walking, plane turning, cleaning action and crossing obstacles.



Figure 2. Four legged wall climbing robot of Carnegie Mellon University

3.2. Other Mobile Technologies

literature[11] proposed a double cavity negative pressure wall climbing robot. The robot adopts a four-wheel drive moving mechanism. The active gear train and the passive gear train are installed on the aluminum alloy framework. The two active wheels are driven by a DC motor and driven by a synchronous belt to move on the glass curtain wall. Through the curtain wall cleaning test, the robot can turn 90 ° clockwise in place, but the process produces a small downward slip, and can span a 20mm groove. The robot

adopts a crawler type moving mechanism. The traction device is composed of four independently driven crawlers, each of which is about 400mm long and 50mm wide. The tracks are placed at the bottom of the robot in pairs. literature[12] studied the wall surface adaptability of tracked magnetic adsorption wall climbing robot. The research shows that the adhesion coefficient between the track and the wall and the load dispersion coefficient directly affect the adaptability of the robot to the wall. The extended tension track and flexible track with rear wheel drive and front wheel floating support can greatly improve the adaptability of the robot. This magnetic adsorption is limited by the surface material of the working environment and is not suitable for promotion and application in the field of glass cleaning.

4. Single Cleaning Technology

literature[13] developed a window cleaning robot. The robot adopts a single cleaning form of roller brush, and the roller brush rotates at a speed of 60R / min by an AC motor. The robot is equipped with four spray heads. The spray heads spray soapy water to the roller brush at a 45 ° angle. The continuous spraying amount is 5S, stop for 10s, and then spray for 5S to make the whole brush obtain soapy water for glass cleaning. In addition, the robot is equipped with photoelectric sensors to check whether it is clean. It has simple structure and can be used for cleaning glass and floor.

5. Development Trend

Multiple machines work together. The collaborative operation of multiple cleaning robots reduces the calculation amount and work area of a single machine, facilitates the optimization of work path navigation, and improves work efficiency, accuracy and cleaning effect. Multi technology integration. Integrate a variety of advanced technologies with the glass curtain wall cleaning robot to make up for the shortcomings and functional defects brought by a single technology, so as to achieve the goal of informatization and intellectualization of modern glass curtain wall cleaning robot. Miniaturization and lightweight. The glass curtain wall cleaning robot is miniaturized and lightweight. On the one hand, it can be portable, easy to store and has little impact on people's life and work; On the other hand, a large number of basic research needs to be solved, such as the coordinated development of battery endurance, material selection, structural design and other aspects. However, the miniaturization and lightweight of glass curtain wall cleaning robot is bound to be an important development trend in the future.

Acknowledgment

Thanks the following funds for their support:
2020 school level science and technology plan project,
Fund No.: 2020KJ02.

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