ABSTRACT: Study high-rise building auto-cleaning machine’s products, working principle and process, analysis of the factors of SET in order to find the product opportunity, optimize structure and shape reasonably, makes the product and the environment more harmonious and more visual recognition, it provides ideas and reference for the breakthrough design of complex mechanical products.

1 GENERAL INSTRUCTIONS

With the development of economy, there are more and more high-rise buildings (10 floors and above or housing height more than 24 meters) [1] in China's large and medium-sized cities. In the decoration of the city landscape, at the same time, the building curtain wall cleaning problems also occur. Due to the low efficiency and high risk factors of manual cleaning, more and more attention are being paid to automatic washing machines. Furlong Hoff production technology and automation research institute of Germany (IPA) develops two kinds of automatic cleaning system, which needs horizontal guide rail and vertical guide groove; SFRI and SFR II [2] and the subsequent cleaning operations, which needs to use the roof of the lifting mechanism to coordinate their movements to achieve bottom-up cleaning operations and through the two bar-type frame structures, the SIRIUSc series [3-4] obstacle and pose adjustment are realized. In recent years, the pneumatic wall cleaning robot with the combination of cylinder drive and sucker adsorption has been developed by Beijing University of Aeronautics and Astronautics[5-6]. Harbin Institute of Technology has developed two kinds of wall cleaning robots including single-sucking dual wheel and double-caterpillar[7-8]. The above research is focused on the innovation of the moving mode and running mechanism of automatic curtain wall cleaning mechanism and neglects the integration of modeling and functional organization. Aimed at such problems, after a thorough understanding of the working principle and working process of the automatic cleaning machine, from the SET (social - economic - technology) factors, the analysis of product opportunity gap[9], rational integration and optimization of modeling and functional mechanism are conducted to design a technically feasible high-rise building curtain wall automatic cleaning machine with a highly visual recognition of appearance.

2 SET FACTOR ANALYSIS

2.1 Product status analysis

From the current input use of automatic cleaning machine, appearance of SIRIUSc wall cleaning robot of German IPA Company is a rectangular box, of which all the agencies are wrapped in it; only a little package decoration is done externally; the remaining mechanical parts, pipeline is exposed in the rectangular shell outside. In material, metal frame is selected, which makes the whole looks very heavy. The visual recognition of it is very poor. If you don’t see the working status, it is difficult to guess the high-level glass cleaning robot; Beijing University of Aeronautics and Astronautics designs washman cleaning robot, which adopts the aircraft modeling and very original. On color matching, red, blue and bright colors are used. In particular, a number of unnecessary pipelines are reduced. However, there is no protective device and there is a lack of safety considerations [5-6]. Harbin Institute of Technology develops washing machine with CLR-I type single-suction double type, which is designed for cleaning the surface of ceramic tiles. On the whole, it looks simple and generous, which uses wrap shape. At the junction of circular and linear, it is over with a small arc, which gives people a good feeling of modern high-tech. However, with only a rinse plate walking around, it can not be clean enough and there is also no security protection measure [7-8]. Technology - the shape of the location map is shown in Fig.1.
2.2 Set factor analysis

SET (social - economic - technology) factor has been presented by Jonathan Cagan and Craig Vogel in 2002. According to this research method, it thinks that breakthrough products come from the combination of form and technology and can create value for the user to create value for the consumer experience. A comprehensive survey of the SET factors can guide the product opportunity gap, which refers to the potential demand of the products caused by the new trend, including the possibility of creating new products or significant improvements to existing products. When the existing products can not fully meet the needs of users in the new trend, new product opportunities will be created [9].

Product opportunity gap is analyzed by using SET factors. As shown in Fig. 2, SET factors are integrated mainly as the following points: ① Cleaning task is heavy and the risk coefficient is big (the floor is getting higher and higher); ② More harmonious and beautiful overall environment is needed; ③ The present cleaning efficiency is low; ④ The utilization rate of water resources is low and personnel costs (including liability and workers’ compensation) are high; ⑤ A variety of key technologies have got very good solution.

3 OPERATING PRINCIPLE AND WORKING PROCESS ANALYSIS

3.1 Operating principle of Auto-cleaning Machine

Based on investigation and survey and analysis to operating principle of existing auto-cleaning Machine, it is found that operating principle of cleaning machine is realized through following three systems[10]:

Cleaning system of cleaning machine: cleaning system consists of rolling brush system, spraying system, recovery system of water circulation, sewage treatment system and cleansing system. Cleaning work is finished through way of joint action of washing, scrubbing and scraping. Rolling brush system is mainly to clean stubborn dirt, spraying system removing little dirt, cleansing system performing eventual cleaning after the ending of former two works.

Wall-climbing system of cleaning machine: Adopting adhesive discs combination structure of vac-sorb and gas drive can effectively meet requirements of load, speed and obstacle crossing. Vacuum absorbing structure is divided into round rotational structure and cross structure etc.

Control system of cleaning machine: programmable logic controller(PLC) is adopted, and wireless operation can be performed through computers on ground to finish adhesive disc separation of main body of robots, noumenon movement, adhesive disc absorbing and sequential control on cleaning etc.

3.2 Working process analysis

Wireless signal is launched when cleaning machine is working. Computers on ground receive signal and control motion path of cleaning machine. Windlass in roof is connected to machine and is provided with corresponding follow-up control unit. Wire cable of windlass can be extended and withdrawn according to kinematic velocity of cleaning machine, which is used to protect and prevent cleaning machine falling from floor due to loss of control, thus ensuring its security. Cleaning machine is adsorbed to wall space through adsorption equipment of wall-climbing system, with air pump vehicle on ground providing machine for high rise building shall be proceeded from the following points: ① safety of the cleaning process (to prevent falling from high altitude); ② sharp shape is needed to enhance the visual identity and its coordination with the environment; ③ efficient cleaning efficiency; ④ good ability to overcome obstacles; ⑤ optimization and integration of structure and shape. After making clear the design direction, the product design of next stage shall be more targeted.
power, and cleaning machine starts to work after receiving instructions.

Movement of cleaning machine adopts cross mode of exercise. It is divided into longitudinal and transverse movement: longitudinal adsorption is at first, doing horizontal movement, and then it is transverse adsorption, longitudinal movement being done alternately. When it is going to arrive at boundary, sensor in boundary sends out signal, and it will changes direction and moves towards underneath. Specific movement is as shown in Fig. 3[11].

3.3 Analysis on controlling process

Automatic cleaning machine control system adopts the two-level controlling structure, composed of three parts, the computer, ground computer and radio frequency communication device; the overall framework is shown in Fig. 4. Cleaning machine control computer adopts high reliability industrial PLC, directly installed in the robot body, receiving information sent by computer on the ground and starts the implementation system, realizing the controlling of the robot motor, clutch, brakes and other parts, so as to complete the command; at the same time, it collects robot’s motion of each time, and sends it to the ground computer, realizing the monitoring function of wall cleaning robot. Ground computer can realize the switch between automatic remote control and manual remote control. The remote control device mainly consists of a radio frequency communication device and a function control button.

4 DISPLAY PROGRAM

The design of automatic cleaning machine of high rise building adopts bionic design concept, the structure of the movement of cross and the material of light aluminum alloys and plastics; the end of the cross frames is installed with edge detection sensor, imitating the foot joint movement of spider, able to pose a variety of walking motion; the cleaning shell is obtained by the cutting and deformation of four bevels; the camera, rings, wireless signal transmitter, air input tube and other devices are installed around, water inlet and dewatering outlet of clean water tank and sewage water tank are put in both sides; the cleaning combines the form of scrubbing, scouring and high-pressure spraying; the internal use of the water cycle structure on the one hand can save the water in the upper air cleaning, on the other hand can reduce the load of their own. The effect and using scene can be seen in Fig. 5(a) and (c).

Through the wireless signal, the cleaning machine is connected with ground computer; the ground computer issues instruction, which is received by internal PLC of cleaning machine and then execute it; ground pump car supplies power to the cleaning machine through the conveying pump tube on the shell; shell ring is connected with the roof winch; hoist is equipped with servo device, the recovery or roping of elongation is according to the movement of the cleaning machine to prevent the sudden drop when breaking down; The camera can transmit the cleaning condition to the ground computer through wireless signals to achieve real-time monitoring. The control process is shown in Fig. 5 (b).
5 CONCLUSIONS

Through technology - modeling location map, the existing automatic cleaning machine products are carried out with positioning of technology and modeling. SET factor is analyzed in order to find the product opportunity gap. The opportunity gap is converted to design direction. A comprehensive consideration and reasonable optimization of model and structure of the automatic cleaning machine is conducted for design scheme. A 3d digital model is established. The improved automatic cleaning machine is reasonable in structure and has a strong visual recognition, of which comprehensive quality and added value have been improved.

REFERENCES