

A Study on the Structural Design and Functional Simulation of an Automatic Cleaning Machine for Dining Tables

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Abstract — Currently there are no cleaning machines for dinning tables available in the market, dinning tables at fast-food restaurants, canteens and the like occasions have to be manually cleaned with cloth as is a convention of hard labor. It takes a great deal of time, labor and water to clean tables properly this way; plus there is no necessary sterilization available. Based on analysis of the perspective users and market demand, an automatic cleaning machine for dining tables has some innovative features in its structure, operating principle, external appearance and color matching. It can make the dinning-table cleaning process quick, automatic, efficient and environment-friendly on the basis of adequate consideration of the combination of functions and easy operation. Our research results can also provide reference for other auto cleaners.

Keywords - mechanical design; cleaning machine for dinning-table; automatic; smart; functional simulation

I. INTRODUCTION

Nowadays, people are leading a modern life at an increasingly fast pace, and various fast-food restaurants have emerged to meet their demand; fast-food restaurants now take as much as 45% [1] market share of the catering business; and numerous plants, companies and schools also operate their canteens. At present there are as many as millions of fast-food restaurants around China. In this new era of blooming economy and technology, we have witnessed various cleaners [2] in our everyday life, and those smart cleaners [3], in particular, have reduced considerable labor intensity and enhanced work efficiency. Nevertheless, there is no automatic cleaner purposefully designed for dinning tables, so dinning tables around these places have to be cleaned manually with cloth. This kind of cleaning presents considerable short-comings: First, low efficiency; Second, considerable waste of detergent and clean water, for there is no clear-cut specification for their

principles, to investigate and design a type of dedicated automatic cleaning machine for dinning tables, to make one-off cleaning of dinning tables quickly.

II. ANALYSIS OF OPERATING PRINCIPLES AND PROCESSES OF THE AUTOMATIC CLEANING MACHINE FOR DINING-TABLE

A. Operating Principles of The Automatic Cleaning Machine for Dining-table

The automatic cleaning machine for dining-table consists of three systems: (1) Cleaning system. It consists of the cleaning brush system, the waste recycle bin, and table-top sterilizing lamps. One-off operation works to do brush-cleaning, scrape-cleaning and UV sterilization of dinning tables. (2) Positioning system. Crosswise horizontal scaling mechanism and lifting mechanism are employed to realize automatic positioning of the automatic cleaning machine to fit the width and height of the table. (3) Control system. infrared sensor control senses and obtains the table height

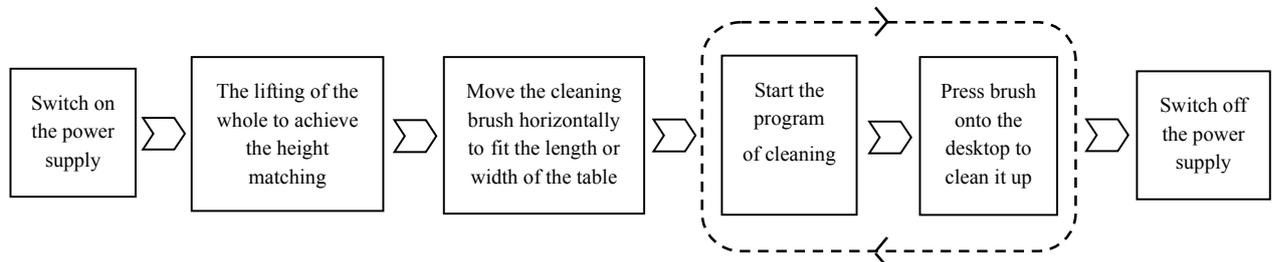


Fig. 1 Operating process of the automatic cleaning machine for dinning-table

consumption; Third, during cleaning, dinning tables are not always sterilized, and the remainder bacteria on the table present some threat to the upcoming diners. Having born in mind the above issues and the market status quo, we optimized rational combination of functions and structural

and width with its ultraviolet radiation, and the sensor gives off commands to conduct overall lifting of cleaning machine, horizontal reciprocating motion of cleaning brushes and cleaning order control.

B. Analysis of Operating Processes of Automatic Cleaning Machine for Dining-table

As shown in Fig.1, the operating processes of automatic cleaning machine for dining-table is as follow: (1) General steps: First, press upon the "Power" button to switch on the power supply, and the infrared sensor works to sense the table top height and width; then press the "Start" button to start the cleaning machine, it moves up and down to achieve the matching of cleaning brush and dustbin, located in the front of cleaning machine, with the height of table desktop, cleaning brush moves horizontally to obtain the location of the length and width of the table desktop, and the brush head

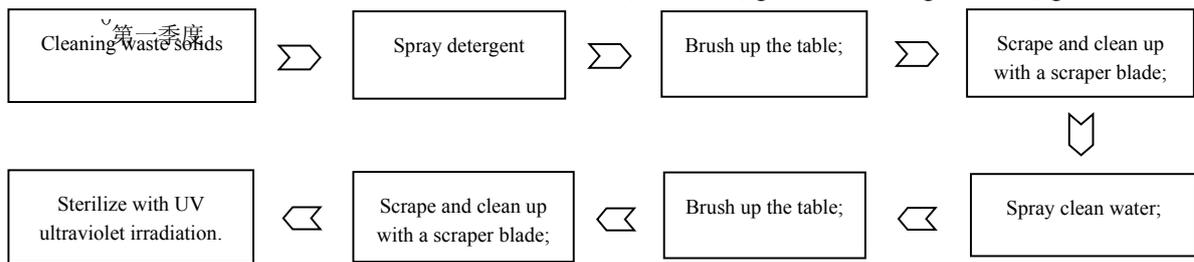


Fig. 2 Cleaning processes of the auto cleaner for dinning tables

will move back and forth to clear up the desktop garbage, clean and sterilize the table desktop. And at the same time, the garbage is collected in the dustbin. Finally, the controller operates to make the cleaner return to the "OFF" state. We press the "Power" button to switch off the power supply, and the whole cleaning process ends. (2) Specific cleaning steps in order: Cleaning waste solids; cleaning greasy dirt; cleaning the table with clean water; and sterilization, as shown in Fig. 2.

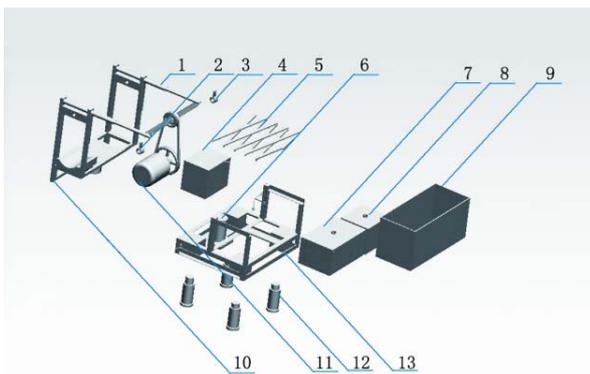


Fig. 3 Exploded view of the interiors of the auto cleaner

III. STRUCTURE DESIGN OF THE AUTOMATIC CLEANING MACHINE FOR DINING-TABLE

A. The Overall Structure

The automatic cleaning machine for dinning-table consists of five components: base, inner parts, outer-casing, cleaning brush and controller. As shown in Fig.3, the inner parts are mainly composed of cleaning brush support rod 1, screw 2, left-and-right screwing nut 3, storage battery 4, crosswise horizontal retractable mechanism 5, cleaning brush elevating shaft 6, detergent spraying mechanism 7, water spraying mechanism 8; dustbin 9, motor fixing holder 10, motor 11; general elevating shaft 12, general elevating

holder13. The cleaning brush support rod 1 is a common retractable rod, which stretches out and draws back with the cleaning brush during the process of retractable operation for brush cleaning. The crosswise horizontal retractable mechanism is a crosswise structure of one rod of the same length, whose end is linked with screw and left-and-right screwing nut. When the cleaning machine runs, the motor drives screw to rotate via the belt conveyor, the left-and-right screwing nut to move relatively on the screw, to help

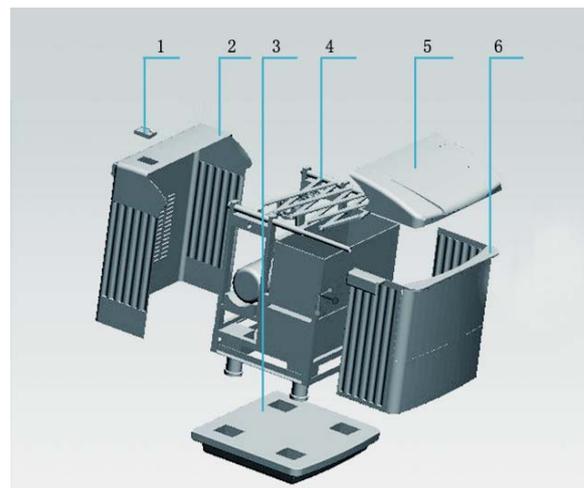


Fig. 4 Exploded view of overall structure of the auto cleaner

the crosswise horizontal retractable mechanism to stretch out or draw back, and thus cleaning brush to move back and forth. General elevating shaft and general elevating holder form up its height positioning elevating mechanism, to

make the cleaning machine ascend in line with undersurface of the dinning table to be cleaned. Both the table height positioning and elevating mechanism and the cleaning brush elevating mechanism have their elevating shaft driven by 24V DC motors.

Fig.4 illustrates the overall structure of automatic cleaning machine for dinning-table. It is mainly composed of control panel 1, rear casing 2, base 3, inner parts 4, cleaning brush 5, front casing 6.

B. The Structure of Parts and Components

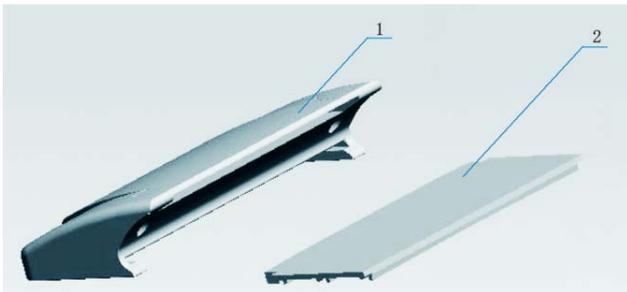


Fig.5 Cleaning brush disassembly view

Cleaning brush: Its structural disassembly is shown in Fig.5, and it consists of two components: brush holder box 1 and brush head 2. The brush holder box features clean water and detergent containers, and is fixed to the crosswise horizontal retractable mechanism and the support rod; the brush head is collapsible and replaceable, whose structure is shown in Fig.6. It consists of 8 components: waste solids scraper 2, detergent spraying tube 3, detergent brush 4, detergent scraper 5, water spraying tube 6, cleaning water

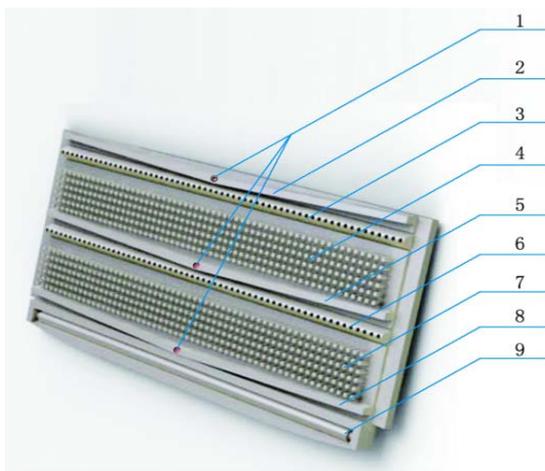


Fig. 6 Structural drawing of the brush head

brush 7, cleaning water scraper 8 and UV sterilizing lamp 9. The rear part of the brush where the solid waste scraper is fixed is furnished with infrared detector 1, which works to detect the height, length and width of the table to be cleaned.

Base: it consists of three components: four wheels 1, support base 2, and shaft hole 3. And each wheel can rotate 360°, and be linked to the support base via the shaft, as shown in Fig.7 (left).

Outer-casing: It consists of two components: front casing and rear casing, and the front casing is fixed onto the base, whose top end is furnished with a infrared sensor to detect the lower surface of the dinning table to be cleaned, and the front head on the upper part of the front casing can be flipped forward and down, so as to draw out wastes easily, as shown in Fig.7(right).

Controller: It consists of four components: control panel, chip, front cover and rear cover.

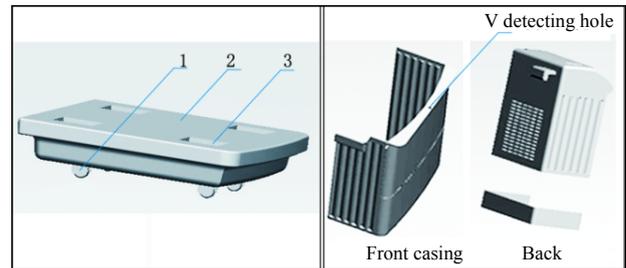


Fig.7 Base and outer housing

IV. APPEARANCE DESIGN OF THE AUTOMATIC CLEANING MACHINE FOR DINING-TABLE

A. Appearance Shape

Shape design of product refers to original and innovative industrial design to facilitate proper structure and functions.[4] To meet the requirements for the structure and functions mentioned above, the appearance shape of the automatic cleaning machine for dinning-table can be square, with inclined arc for product top and front end; having taken rational structure and functions in mind, we should make the product as small as possible to facilitate portability of the cleaner.

B. Appearance Color

Color matching for industrial products is not only of visual aesthetics, but more importantly involves their functions and surroundings; efforts shall be made to coordinate human, the machine and the environment, and to maximum work efficiency and optimal functions. The automatic cleaning machine for dinning-tables is applied to the occasions where people have their meals, and its color shall be in line with such psychological demand of people out there[5]; it shall look clean, hygienic, and healthy, facilitating their appetite. Thus, red (R: 164, G: 79, B: 82) and white (R: 255, G: 255, B:255) colors are coordinated together, supported by blue (R: 26, G: 218, B:247) and gray (R: 222, G: 233, B:235) colors too, as shown in Fig.8. And Fig.9 also shows its working status.



Fig. 8 Color matching of cleaning machine



Fig. 9 The working status of cleaning machine

V. THE SIZES AND HUMAN-MACHINE ANALYSIS OF AUTOMATIC CLEANING MACHINE FOR DINING-TABLE

Human machine analysis means the analysis of interaction between human, the machine and the environment. The automatic cleaning machine for dining tables is designed for the user to operate with standing and move frequently, whose size has to meet functional and structural requirements primarily; Apart from the comfort and convenience during operation, the surrounding space for location and operation shall also be attached importance to.

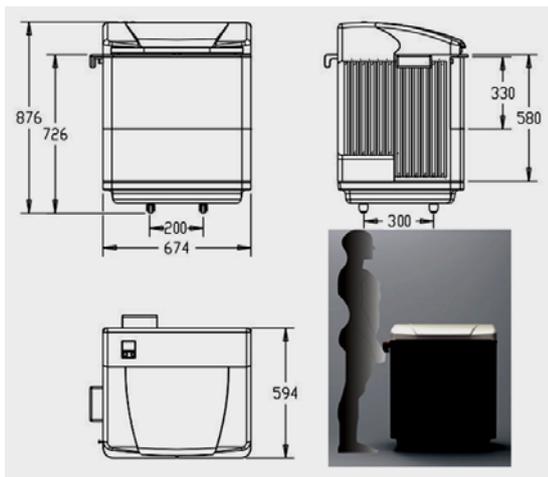


Fig. 10 The size of the automatic cleaning machine for dining tables and comparison chart between cleaning machine and human body posture of standing

The size of the automatic cleaning machine for dining tables involves outline dimensions, handle size, height, lifting dimensions and so on. The outline dimensions are constrained by five aspects: internal motors, dustbin, retractable cleaning brush, product package for transportation and the setting, so the overall size is: 674 mm (L), 594 (W) and 876 (H). According to GB/T 10000-1988E Human Body Sizes in China [6], choosing the 50 percentile sample adults and using their palm sizes [7], the handle size is defined as 28mm, whose location height is, in line with comfort handling of a standing adult[8], designed as 726mm. The comparison chart between cleaning machine and human body posture of standing is also provided in Fig.10.

A. Human-machine analysis between the automatic cleaning machine for dining-table and the operators

The human-machine analysis between the automatic cleaning machine for dining-table and the operator mainly involves the interaction between operators, and the control panel, the handle and the waste collecting opening. According to GB/T 10000-1988E Human Body Sizes in China [6], adults from 18 to 35 years old have their elbow at the height of 960 mm on average when standing up.

Having born this in mind, we considered the comfort height of 850mm 900mm recommended in western countries for light labor work, plus 20mm for shoe heel height, we place the operating control panel on the upper surface of the cleaner, which is 876 mm from the ground, as serves the user in their leisurely operation of the cleaning machine and reduces their mis-operation. To help the user to push the cleaner forward and turn it around at ease, handles are places on the sides and the back, and their location height is 726 mm above the ground, considering the shoe heel height of 20mm, and the easy operation height of 704 mm for the user to bend forward to push the cleaning machine; the garbage fetching opening is located on the front and upper part of the automatic cleaning machine. To take the garbage, the operator can just flip down the head board on the upper part of the front casing, when the whole dustbin can be taken out as a whole horizontally. It does not take much force or time to pull at all.

B. Human-machine analysis between the automatic cleaning machine for dining-table and the environment

The automatic cleaning machine for dining-table mainly runs between tables, so their motion and operation shall meet the standard and criteria for dining environment and passageway for all diners in particular. According to interior ergonomics [9], the main passageway width for dining environment is 1200mm 1300mm, and the minimum width for a person to walk forward and pass is 520mm. The running route for the cleaning machine during operation can be straight, bending turn, or returning. When it moves straight forward, the operator staying behind the automatic cleaning machine in the same longitudinal line does not occupy additional passageway width. Thus the operation width for the automatic cleaning machine for dining-table is 594mm, and the passageway width for the operator is

606mm 706mm, which is wider than 520mm, so it is enough for the operating automatic cleaning machine for dinning-table to pass through. When it turns left or right, or turns around, the cleaning machine runs like an automobile, and its turning radius can be calculated with the same minimum radius for a car [10]. The front wheels for the cleaning machine are universal wheels, able to move freely 360°. The distance between the front and rear wheels is 300 mm, and that between the left and right wheels is 200 mm, so the turning radius is 360mm, and the passage width for such purpose is $360\text{mm} \times 2 = 720\text{ mm}$, which is less than 1200 mm, so the automatic cleaning machine for dinning-table can turn left or right, and turn back on the passageway easily.

VI. CONCLUSION

An automatic cleaning machine for dinning-tables is meant to address the existing short-comings of the conventional dining table cleaning mode, so a brand new cleaning mode has been designed to enhance the cleaning of dinning tables. The automatic cleaning machine for dinning-tables impresses us most with its quick and complete cleaning of wastes, greasy dirt and water. At each cleaning, it also works to sterilize the dinning table, and remove the remainder bacteria, to provide a favorable environment for the upcoming dinners. Its specific advantages can be summed up as follows:

First, optimal structural design has been made to realize quick and automatic cleaning of dinning tables, and one-off cleaning helps to remove various wastes, collect wastes, and sterilize the dinning tables all at once.

Second, simple structure and easy fabrication helps reduce costs, and on common operating setting, an automatic cleaning machine for dinning-table has a service life of 3-5 years.

Third, the automatic cleaning machine for dinning-table is in line with human-machine engineering principle, and the user can operate promptly at ease and with comfort and efficiency;

Fourth, concise appearance make it a graceful whole, in harmony with the surrounding environment.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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