AN INTELLIGENT DEVICE FOR MASK DISPOSAL AND CLEAN MASK OFFERING

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Abstract: - *Based on investigations of current mask treatment situations and requirements, an intelligent device is designed for disposing of used masks and offering clean masks. The multi-function intelligent device is small in size and simple in operation. Contactless delivery and automatic disposal of used masks can be achieved. Ultraviolet disinfection and automatic packaging of used masks will be carried out subsequently. The requirement of providing clean masks can be also addressed in this device. The application of this intelligent device can be promoted in communities with a large stream of people, such as schools, hospitals and shopping malls.*

Keywords : - *Mask Disposal, Mask Disinfection, Contactless Delivery, Automatic Packaging, Clean Mask Provision*

I. INTRODUCTION

With the increasing attention to public health safety, the demand for masks has increased dramatically. The service time of a clean mask should be noted. According to China WS/T311-2009 Technical Specification for Hospital Isolation, the efficacy of medical protective masks should be continuously applied for 6-8 hours[1]. The mask should be replaced in time when contaminated or humid. During the outbreak of COVID-19 pneumonia in 2020, the China National Health and Health Commission issued guidelines for the use range of common medical protective devices in the prevention and control of pneumonia caused by new coronavirus infection. The medical-surgical masks and medical protective masks should be replaced at 4 hours in the fever clinic and various isolation wards [2]. They should be replaced at any time when contaminated or humid. Generally, masks used by common healthy people could be reusable without special requirements for wearing time, but can not be reused more than 5 times. The reused masks should be replaced immediately when the protective performance of the mask is reduced due to deformation, moisture, or contamination.

Currently, the existing mask disposal devices on the market have a single function without centralized disinfection and automatic packaging of used masks[3-4]. It should be paid attention to the secondary pollution of used masks. Therefore, it is necessary and of great practical significance to design an intelligent device for disinfecting and disposing of used masks in the field of medical and health protection.

II. THE DESIGN SCHEME OF THE DEVICE

A. Display of The Device

The intelligent device for mask disposal and provision consists of six parts: power supply unit, mask delivery slot, mask disinfection unit, mask packaging unit and clean mask offering unit, as shown in Figs. 1. Power supply unit includes motor, control board, and control board power supply, which provides energy for the whole device to ensure the operation; mask delivery slot includes delivery cover, delivery mouth and ultrasonic distance sensor to achieve contactless delivery; mask disinfection unit includes delivery box, disinfection box and ultraviolet lamp tube to realize centralized disinfection of used masks; mask packaging unit includes mask compaction device, mask collection box and automatic packaging device; clean mask offering unit includes a mask storage tank, two pulleys, conveyor belt and push hook.

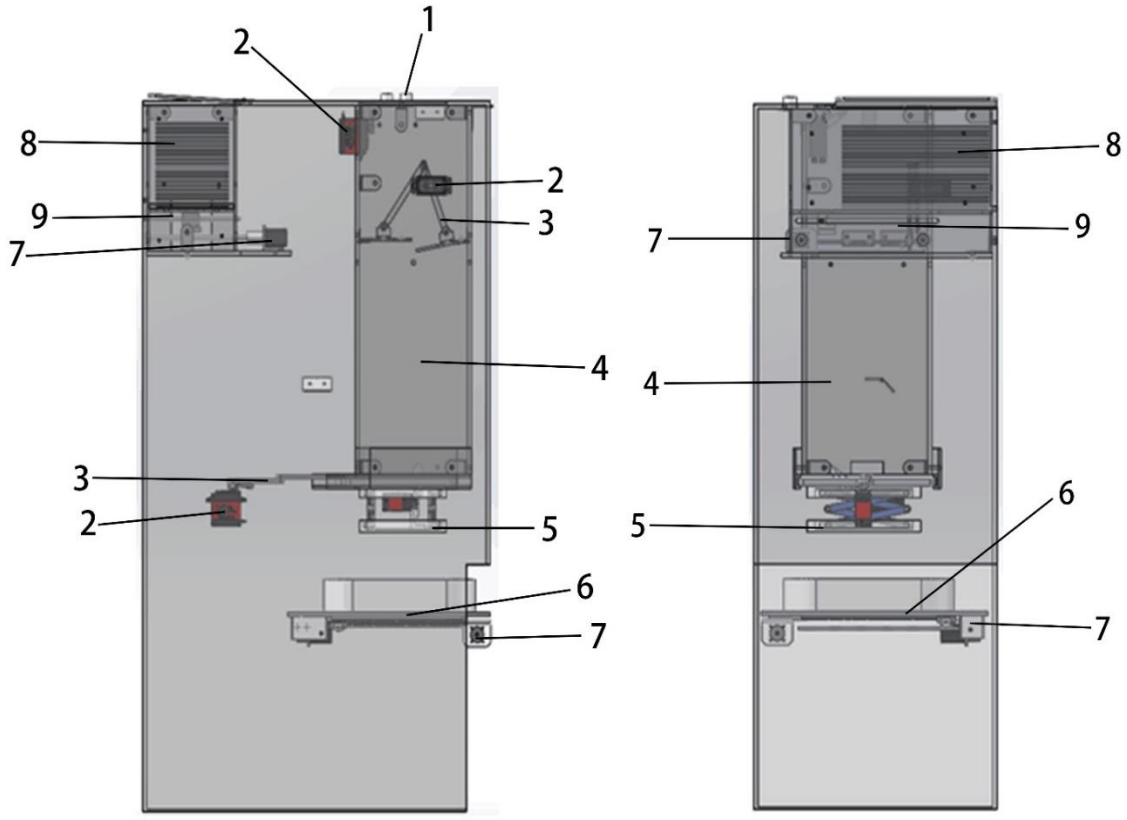

Fig. 1 Diagram of the overall structure (1: Cover of the delivery box; 2: Steering gear; 3: Connecting rod; 4: Disinfection box; 5: Scissor lift assembly; 6: Automatic packaging structure; 7: Motor; 8: Clean masks; 9: Clean mask offering structure)

B. Workflow of The Device

When the user is delivering a used mask, the cover of the delivery slot will be automatically opened after the user's hand is sensed by the infrared sensor. If the amount of discarded masks stored in the collection box reaches a certain number, the cover of the disinfection box will be automatically opened. Then, these used masks fall into the disinfection box where

ultraviolet light is used to sterilize the masks. After that, the masks are transferred to the mask collection box and the compaction device is start to compact the masks. When the volume of the discarded masks in the collection box exceeds the warning line, the automatic packaging device starts to package the garbage bag. The work procedure of the intelligent device is shown in Fig. 2. Meanwhile, when the user's need for a clean mask is received by the intelligent device, the pulleys in the clean mask offering unit are driven to move the conveyor belts. The push hook fixed on the conveyors is moved to push the clean mask which is at the bottom out of the mask storage tank.

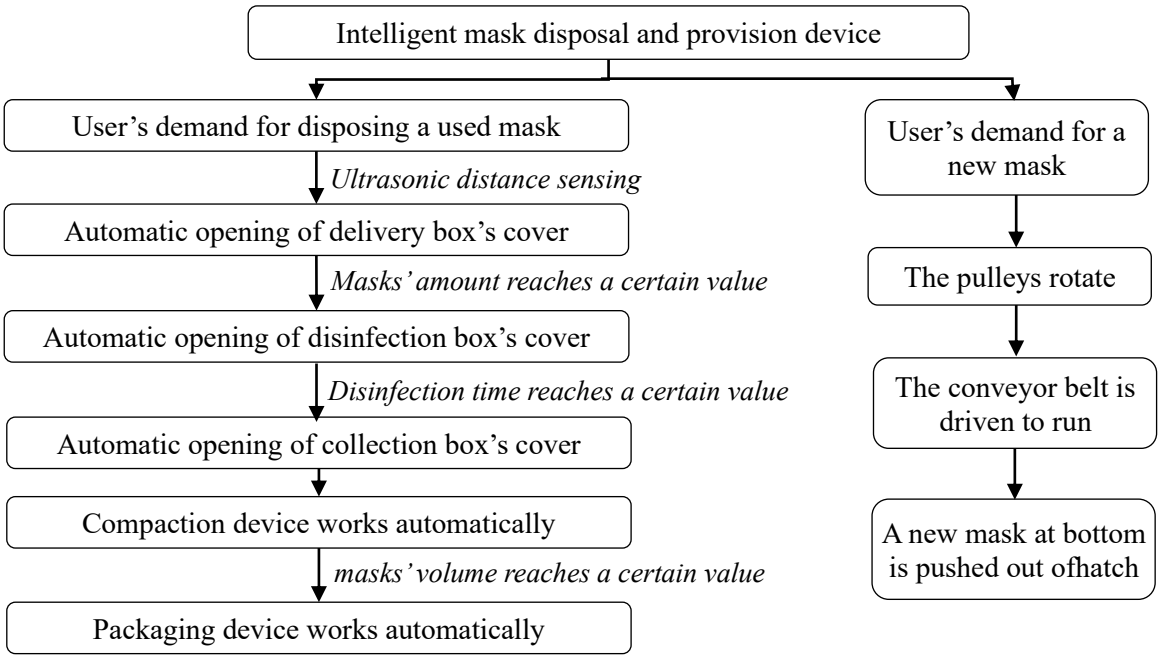

Fig. 2 Flow chart of the device's working procedure

C. Mechanical architecture and control strategy

1) Disinfection Box Cover

A counting program is set in the delivery unit. When the number of the used masks that fall into the delivery box reaches a certain value, the motor is driven to open the cover of the disinfection box. As shown in Fig. 3, the two doors are articulated to the Y-type connecting rods and the crank is connected with the stepper motor. The motor drives the crank to rotate, leading to the movement of the Y-type connecting rods and the opening of the cover of the disinfection box. Then, the mask will fall into the disinfection box for unified disinfection.

2) *Compaction structure*

The compaction of used masks is achieved by a scissor lift assembly, as shown in Fig. 4. The scissor lift assembly is fixed in a slider that is connected to a crank-rocker mechanism. The motor drives the crank-rocker mechanism to make the slider move left and right along slide rails. When the slider is located on the top of the mask collection box, the scissor lift assembly is driven to work for the compaction of the used masks.

3) *Automatic packaging structure*

The automatic packaging structure is shown in Fig. 5. Two perpendicular bars are fixed on two perpendicular synchronous belts, refer to as the *x*-axis bar and *y*-axis bar. When the two motors are running, the belt wheels are driven to operate the synchronous belts. The *x*-axis and *y*-axis bars are taken to the opposite sides smoothly. The movements of the two perpendicular bars push the garbage bag to a ceramic hot melt core [5]. The garbage bag which is full of used masks is packaged automatically after the top edges of the garbage bag are gathered around the ceramic hot melt core and melted together.

4) *Clean mask offering structure*

The clean mask offering structure is consist of a mask storage tank, two pulleys, two conveyor belts and a push hook, as shown in Fig. 6. The push hook that is fixed on the two parallel conveyor belts could move forward and backward when the conveyor belts are running due to the rotations of the pulleys driven by a motor. A clean mask at the bottom of the mask storage tank will be pushed out by the push hook and transported through the discharge hole of the clean mask storage tank. In addition, the top cover of the storage tank could open for the supplement of clean masks.

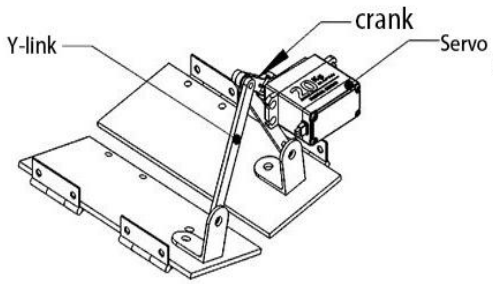

Fig. 3 The structure of the disinfection box cover

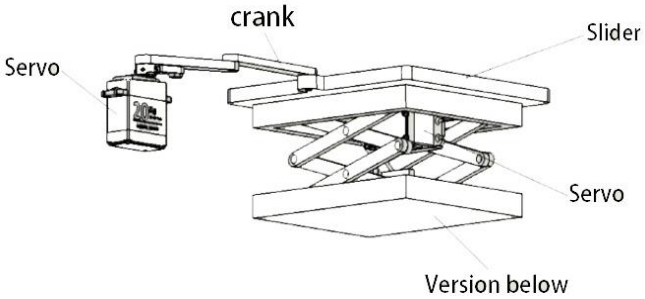

Fig. 4 The compaction structure

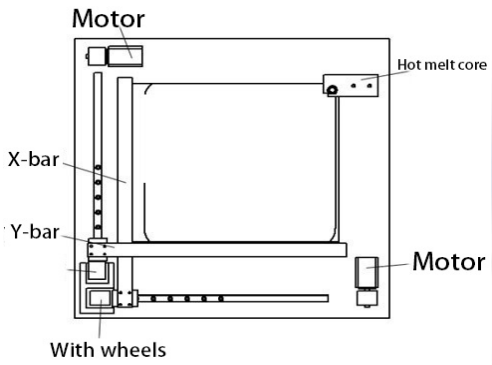

Fig. 5 The automatic packaging structure

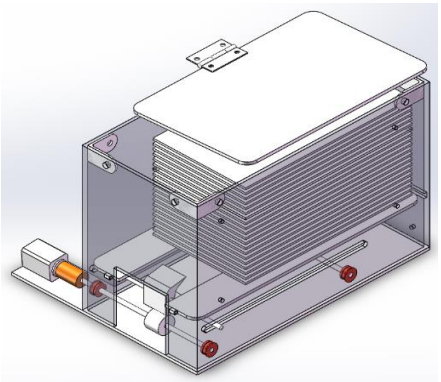

Fig. 6 The clean mask offering structure

D. Sensors and electrical architecture

1) Ultrasonic Distance Sensing

To facilitate the user's contactless delivery, an ultrasonic distance sensor is used to control the rotation of a steering gear [6]. There are four pins in the ultrasonic distance sensor, involving a 5V power supply, GND, ECHO, and TRIG. A high-level pulse with a period of 10 μs is sent through TRIG and the returned data is detected through ECHO. The four-channel steering gear is driven by a 25 V-GS battery. The four channels in the steering gear are named as DuoPIN, DuoPIN1, DuoPIN2 and DuoPIN3, respectively. The pins connected to a single-chip microcomputer are determined as 3, 5, 6 and 11, respectively. The corresponding rotation angles of the steering gears controlled by the output of the PWM (Pulse-Width Modulation) port are -65 ~ 65 °, -120 ~ 120 °, 0 ~ 150 ° ~ 0 and 60 ~ -60 °, respectively. After the sensor receives the feedback data, a signal will be transmitted to a microcontroller. Then, the microcontroller will send a PWM wave to control the steering gear to finish the rotation with the designed degree.

2) *USART HMI Serial Screen*

In order to improve public awareness of the hazards of abandoned masks and display the operating instruction of the smart device, a USART HMI serial screen is implanted to broadcast promotional videos circularly. The display screen has its own GUI (graphical user interface), which can be directly used with a power supply. The controlling parameters can be modified using serial communication. It is convenient to use the serial module with the serial ports of USB and TTL to transfer data from the computer to the display screen, as shown in Fig.8.

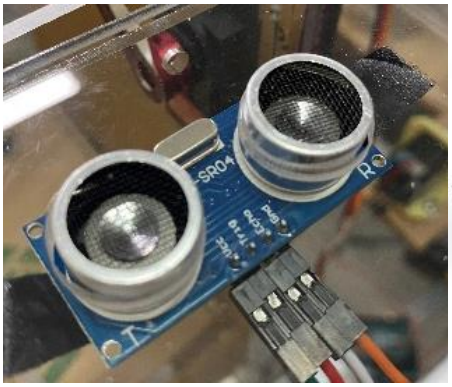

Fig. 7 The ultrasonic distance sensor

Fig. 8 The serial communication module

III. CONCLUSION

In this paper, an intelligent device for disposing of used masks and offering clean masks is developed based on KEIL5. Two modules referring to the disposal of used masks and offering clean masks are integrated into the device through electromechanical integration design. Multi-functions can be achieved in the intelligent device, involving contactless delivery, automatic disinfection, automatic disposal, automatic packaging of used masks and providing clean masks. Meanwhile, the device is small and simple in operation. It is of great significance to place the intelligent device in the communities with a large stream of people, such as schools, hospitals, and shopping malls.

Acknowledgment

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