Design and Research of an Intelligent Medicine Box

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Abstract. In order to solve these problems, such as forgetting to take medicine, wrong dosage or type of medicine, an intelligent medicine box is designed. The intelligent medicine box is composed of a piston dispensing mechanism, a platform moving mechanism and a main body mechanism, etc. Close cooperation between various parts, realize the functions of storing medicines, automatically dispensing medicines, intelligent reminders, intelligent detection and intelligent sterilization. Through the simulation in solidworks, the mechanical performance simulation analysis. The results show that the deformation of the crank is very small during the whole process of dispensing medicines, there is no concentrated stress, and it has no effect on the dispensing efficiency during the dispensing process. The designed intelligent medicine box is not only for the elderly, but also suitable for all kinds of people. It can promptly remind patients to take drugs, reduce the occurrence of problems such as wrong medication and forgetting to take drugs. It is user-friendly in design, simple and convenient to operate, helps smart medical treatment, eases the pressure of medical care, and has good market application value.

1. Introduction

In the 21st century, the world is generally faced with the problem of aging population, followed by the health problem of the elderly. The life style, life style and life attitude of the elderly are obviously different from other groups[1-4]. In addition, the elderly are prone to memory decline, there will always be the phenomenon that the elderly forget to take medicines or take the wrong kind of medicines, which has a great impact on the elderly's health[5]. Due to the development of science and technology in the current era, most of the elderly are more difficult to use the over intelligent products, and sometimes have fear and rejection[6-8]. At present, most of the medicine boxes on the market are simple storage boxes. Most of the medicine boxes with intelligent reminder function are more complex and expensive to use[9]. Therefore, an intelligent medicine box device is designed, which can deliver medicine on time according to the quantity, and the operation is simple, which can better solve the problem of the elderly taking medicine. This device is based on timely reminder, accurate quantity of medicine, simple operation and convenient use, so that the elderly can take medicine more safely and conveniently.
2. Another section of your paper

2.1. Structure composition

The intelligent medicine box includes three parts: piston medicine delivery mechanism, platform moving mechanism and main body mechanism. The outer wall of the medicine tube of the main body is cylindrical, and the inner part is empty. The inner hollow shape is the same as that of the medicine. The medicine tube is divided into tubular area and semi tubular area. The tubular area is a cylindrical hollow tube, and the bottom of the medicine tube is up 3cm, which is a semi cylindrical tubular structure, which is a semi tubular area. The piston medicine delivery mechanism is fixed at the bottom of the main mechanism, and the platform moving mechanism is fixed at the back plate of the main mechanism. The piston in the piston medicine delivery mechanism is assembled in the medicine tube of the main mechanism, and the piston medicine delivery mechanism contains four identical devices, which are respectively matched with the corresponding medicine tube. The gear of the medicine delivery mechanism of the piston is meshed with the internal gear of the third platform in the platform moving mechanism. The gear and crank in the medicine delivery mechanism of the piston are fixed in the same shaft, and their rotation speed directions are the same. The motor in the third platform on the platform moving mechanism drives the gear to rotate, drives the crank to rotate, and makes the connecting rod drive the piston to move in a reciprocating straight line. During the reciprocating movement of the piston, when it moves to the bottom, a certain gap is formed between the upper part of the piston and the semi tubular area at the bottom of the medicine tube, and the medicine falls from the gap. The overall structure is shown in Figure 1 and Figure 2.

![Axonometric drawing of overall structure](image1)

Figure 1  Axonometric drawing of overall structure

![Front view of overall structure](image2)

Figure 2  Front view of overall structure
2.2. Working principle of the device

Before using, the user should put the tablets or capsules into the tube one by one. The device needs to be set up according to the number of times and quantity taken in the medicine instruction. In order to facilitate the use of the elderly, we use different control methods for different types of the elderly. For some old people who are used to using mobile phone wechat, they can use wechat to scan the QR code on the medicine box to enter the wechat applet to connect with Bluetooth for setting. For some old people who are not good at using mobile phone, they can use the touch screen on the medicine box to set parameters directly. When the user uses, the internal platform moving mechanism of the device is matched with the gear of the piston medicine delivery mechanism to drive the piston to move in a reciprocating straight line, so as to make the medicine delivery of the medicine box accurate. When the medicine falls, the intelligent infrared detection system will detect whether the number of dropped medicines is equal to the set value. If the quantity of medicine discharged is inconsistent with the set value due to the mechanical failure of the device, the voice module controlled by the single chip microcomputer in the device will sound to prompt the user that the quantity of medicine is wrong, the user can clean up the medicine storehouse and choose to discharge the medicine again. The medicine falls into the lower slide, and according to the inclination of the slide, the medicine falls into one side of the medicine bin. The user only needs to take out the medicine storehouse from the device along the slide way of the medicine storehouse. Slide the medicine bin into the device after use. The operation flow chart of the whole process of medicine delivery is shown in Figure 3.

3. Structure design of the device

The piston medicine discharging mechanism and the platform moving mechanism are fixedly assembled in the main body of the medicine box. The slide way in the main mechanism is directly under the medicine tube. The two medicine storehouses are respectively assembled on the left and
right sides of the main mechanism. The steering engine under the slideway is connected with the connecting rod. The steering gear below the slideway is connected with the connecting rod, and the slideway is connected with another connecting rod. The two connecting rods make the slideway, two connecting rods and the steering gear form a four-bar mechanism, and the tilt of the slide is controlled by the steering gear rotation. When the slideway is inclined, the inclined sideway of the slide is connected with the medicine storehouse.

3.1. Design of piston delivery medicine

The piston medicine discharging mechanism is fixed on the bottom plate of the main mechanism, and the piston is connected with the medicine tube. The piston delivery medicine mechanism plays an important role in the process of medicine delivery. As shown in Figure 4, The piston is a cylinder. There is a circular hole on the non-circular surface of the piston, and there is also a circular hole on one side of the connecting rod. The circular hole on the piston is matched with the circular hole on the connecting rod through the LM shaft, so that the piston is assembled on the connecting rod. In the same way, the circular hole on the other side of the connecting rod is assembled on the circular hole of the crank. In the same way, the circular hole in the center of the crank is connected with the inner hole of the gear, so that the connecting rod, piston, crank and medicine tube constitute the crank slider mechanism. Through the rotation of the gear, the crank is driven to rotate, and then the piston on the connecting rod is driven to reciprocating linear motion.

![Figure 4 Schematic diagram of piston medicine delivery mechanism](image)

3.2. Design of platform mobile mechanism

As shown in figure 1 and 2, the design of platform mobile mechanism includes platform lifting mechanism and platform translation mechanism. The platform lifting mechanism is composed of a first platform, a second platform, a lead screw stepping motor, a lead screw nut and an LM shaft. The lead screw nut is installed on the first platform, and the lead screw stepping motor is closely matched with the lead screw nut. The motor support is made of ABS material. The support can fix the motor and the LM shaft. The lead screw stepper motor and the LM shaft are fixed on the left side of the outer wall of the shell of the main structure through the motor support. A fixing device is set above the lead screw and the LM shaft, which is also fixed on the outer wall. The lead screw and the LM shaft are fixed through the fixing device to make the LM shaft of the lead screw more stable. The first platform is equipped with linear bearing. The linear bearing of the first platform is matched with the LM shaft, and the screw nut is matched with the screw. By fixing the LM shaft and the lead screw, the degree of freedom of the first platform is reduced to 1, which can only move up and down. As shown in Figure 5, the same device is symmetrically fixed on the right side of the outer wall of the shell, the second platform replaces the first platform, and the stepper motor can be mounted above the second platform.
In the platform translation mechanism, both ends of the belt are fixed at both ends of the platform, and the belt and the third platform form a closed figure. The gears connected with the stepper motor on the second platform are closely matched with the belt, and the gears and bearings are respectively located at both ends of the belt. The third platform is fixed on two LM shaft connected with the first platform and the second platform. The centers of the two LM shaft and the belt center are on the same plane, so that the freedom of the platform is reduced to 1, and it can only move in one direction. The stepper motor on the second platform drives the gear to rotate, the gear drives the belt to rotate, and then drives the platform to move left and right.

The design of platform moving mechanism enables the third platform to move in any direction on the plane, and the gear on the third platform can cooperate with any gear in the piston medicine delivery mechanism.

![Figure 5 Schematic diagram of platform lifting mechanism](image)

**4. Function design of intelligent medicine box**

The elderly can set the time to be reminded and the quantity of each medicine through the display screen on the upper board of the main body or through wechat scanning code to enter the wechat applet connection device Bluetooth. Two infrared detection devices are arranged inside the device. One infrared detection device is placed under the upper plate and fixed at the upper plate, which can be used to detect the quantity of medicines put by users; Another device is placed above the slide to detect the amount of medicine. The medicine falling is monitored by the infrared ray emitted from the infrared emitting tube in the infrared detection device. Because the medicine is blocked and reflected to the infrared receiving tube, the counting system in the infrared detection device automatically counts and transmits the value to the single chip microcomputer. If the actual number of medicine delivery is different from the previous set value, the MCU controls the voice module to prompt "error" and control the display screen to display "this medicine delivery failure". If the total count quantity is the same as the previous set value quantity, the voice module controlled by the single chip microcomputer will remind the user to take medicine. When the user puts in the medicine, the infrared detection module counts and sends the recorded quantity to the MCU, which is stored in the MCU. The single-chip microcomputer has the function of counting, which can determine the medicine stock in the medicine tube by calculating the number of medicines each time. If the amount of stored medicines is too small to meet the requirements of the next medicine delivery, the display screen and voice module will remind the elderly to supplement medicines in time. The elderly can set sterilization time on the mobile phone or display screen, and directly control the ultraviolet lamp by single chip microcomputer to achieve the effect of internal sterilization.

**5. Design and calculation of intelligent medicine box**

*5.1. Dimension calculation of inner diameter of medicine tube*

Through extensive access to medicine information, analysis of the most commonly used capsules and pills, and make a statistical table, as shown in Table 1.
Table 1 Common capsule size

| Specifications         | 00#  | 0#  | 1#  | 2#  | 3#  | 4#  |
|------------------------|------|-----|-----|-----|-----|-----|
| Cap mouth diameter     | 8.48 | 7.58| 6.82| 6.35| 5.86| 5.33|
| Total length after locking | 23.3 | 21.2| 19.0| 17.5| 15.5| 13.9|

The intelligent medicine box selects two models with wide coverage in the capsule, and finally makes the medicine tube with inner diameter of 6.10 mm and 8.10 mm. The other specifications of medicine tube are customized according to the parameters of other pills.

5.2. Crank force calculation

Through the inquiry of information to find out the elderly often take several kinds of medicines and query the quality of medicines.

Table 2 The quality of frequently used medicines

| medicine name | Clostridium Butyricum Tablets | Compound amino acid capsules | Ibuprofen Tablets | Jingwu capsule | Lianhua Qingwen Capsule |
|---------------|--------------------------------|-----------------------------|-------------------|----------------|-------------------------|
| Weight per pill | 0.35g                          | 0.35g                       | 0.1g              | 0.45g          | 0.35g                   |

Figure 6  Schematic diagram of piston medicine delivery mechanism

As shown in Figure 6, AB is the crank, BC is the connecting rod, and piston C is a cylinder with a diameter of 8.1 mm and a height of C, where C = 10 mm. If the crank is connected with the motor and the motor speed keeps constant, the AB angular velocity is a constant. x is the distance between the point projected from point a to point C and point C. It is assumed that the direction of projection point a to point C is positive downward. L is the distance from point a to the lower wall of the cylindrical area of the pipe, l = 19.27mm. Let the angle between AB and horizontal line be $\theta$.

$AB \cos(\theta - 10^\circ) + BC \sin(a) = h$

(1)

According to the design parameters, $h=30$mm , $AB=11$mm, $BC=27.5$mm can be determined.

The maximum positive angle is the angle of crank and connecting rod on the same line. The following formula can be listed and solved to get $\theta = 48.8107^\circ$, $a = 51.1893^\circ$.

$\begin{cases} 
\theta - 10^\circ + a = 90^\circ \\
(AB + BC) \cos(\theta - 10^\circ) = h 
\end{cases}$

(2)

The distance between the piston and the upper tube wall must be greater than the maximum length of the capsule. The following formula can be listed.

$L + x - \frac{C}{2} \geq max$

(3)

The value range of x is $x \geq max + \frac{C}{2} - L = 9.03mm$, and the value of x is 10mm.

$\begin{cases} 
AB \cos(\theta - 10^\circ) + BC \sin(a) = h \\
AB \sin(\theta - 10^\circ) + BC \cos(a) = x 
\end{cases}$

(4)
According to the above formula, the maximum negative angle of \( a \) is 45.77 degrees, The value range of \( x \) is \(-29.9445^\circ \leq \theta \leq 48.8107^\circ\).

From the following formula, we can get the relationship between \( \theta \) and \( a \), and get the function image of \( \theta \) and \( a \) through MATLAB. The function image is shown in Figure 7.

\[
AB \cos(\theta - 10^\circ) + BC \sin(a) = h
\] (5)

![Figure 7](image)

**Figure 7** The functional relationship between \( a \) and \( \theta \)

The force of piston at point C is analyzed, as shown in Figure 8.

![Figure 8](image)

**Figure 8** Force analysis diagram

According to the survey data, among the five commonly used medicines for the elderly, Jingwu capsule is the largest in quality, with 0.45g for each capsule, and 20 capsules can be filled by a medicine tube. The total mass of 20 tablets is \( m = 9g, G = 0.0882N \). List the following formula and find the result as \( F_{mg} = 0.08686N \).

\[
mg = F_{mg}/\cos (10^\circ)
\] (6)

The following formula can be listed from image 8, and the relationship between \( F \) and \( \theta \) can be drawn by MATLAB. When \( \theta = -29.8845^\circ \) is found, the maximum value of \( F_{max} \) is selected as \( F_{max} = 0.1399 \), as shown in Figure 9.

\[
F \cos(\alpha) = F_{mg}
\] (7)
6. Finite element analysis
The material is ABS, the elastic modulus is 2Gpa, the Poisson's ratio is 0.394, the mass density is $1020 \text{kg/m}^3$. The stress nephogram is obtained by applying $0.134 \text{N}$ force to the two connecting rod holes on the crank. The crank stress nephogram is shown in Figure 10. It can be seen that in the process of medicine delivery, the deformation caused by the external force on the crank is very small, and there is no phenomenon of concentrated stress.

7. Conclusion
The intelligent medicine box proposed in this paper realizes timely reminder, medicine delivery according to quantity and intelligent control. It effectively solves the problem that the elderly forget to take medicine and take the wrong kind of medicines. At the same time, it uses wechat end and medicine box end to control, which makes it more convenient for the elderly to use. In this paper, through the force calculation and Mechanical Properties Simulation Analysis of the crank, the results show that the deformation of the crank is very small in the process of medicine delivery, and there is no concentrated stress phenomenon, which has no effect on the medicine delivery efficiency in the process of medicine delivery. The intelligent medicine box is easy to use and easy to set up, which can meet the needs of patients taking medicines, and has great significance for assisting patients to take medicines.

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