

# INTEGRATED DESIGN OF HOUSEHOLD GARBAGE CLASSIFICATION, COMPRESSION AND PACKAGING EQUIPMENT

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**ABSTRACT:** A kind of household trash can be based on automatic control is developed which is safe, reliable, efficient, and convenient and the working principle of the device is introduced. Under the condition of meeting the design requirements and actual working requirements, the whole control mechanical system and control system are developed and designed by virtue of mechanical analysis and test method, which can satisfy the functions of automatic classification, compression and packaging. The development of household garbage classification, compression and packaging equipment will produce great social and economic benefits.

**KEY WORDS:** Home trash can, Automatic compression, Packaging.

## 1 INTRODUCTION

With the improvement of the living standard of people, the variety and quantity of domestic garbage is increasing day by day, but the way of waste collection is single. The household garbage is collected by the residents themselves first, and then by the community cleaner for detailed classification. Some residential areas use the garbage facilities and equipment to meet the needs of a large number of residents and the needs of sorting collection by the community cleaner. At present, the garbage collection equipment of the residents doesn't have the function of sorting and effectively collecting, and the collection links are many, wasting manpower and material resources (Srivastava and Nema, 2011). The garbage can be divided into three categories: the kitchen garbage, including leftovers, animal and plant bodies and paper napkin, accounting for about 76.04%; the packing bag trash, including the packing bags of various foods and articles and plastic bags; and a variety of solid waste which can be preserved, including textiles, woods, plastics, metal, glass, drugs, etc. The latter two accounts for 21.96% of the total. There is also the bathroom garbage, which accounts for 2%. But the waste treatment facilities are perfect, not posing any threat to the environment, so it is not included in the scope of urban residents' living garbage. At present, the common collection methods are as follows: the kitchen waste is broken and discharged through the sewer, and other household garbage is packed in a plastic bag and thrown into the garbage can (Chen and Fang, 2014). The disadvantages of

these two treatment methods are as follows: it is easy to cause blockage in the sewer, and peculiar smell and energy consumption are generated. In addition, the waste is mainly stored in the garbage bins and collected in plastic bags. The recovery rate and the degree of automation are low. The above waste treatment methods still lack the functions of garbage sorting, compression and packaging. New technologies for household waste collection and disposal should be developed to achieve domestic waste classification and effective collection and reduce the process of garbage collection, which will effectively control the garbage pollution and wasting of resources.

Investigations indicate that the demand of households and office areas for garbage collection and classification and odor treatment is high and that there is a considerable demand for this kind of waste automatic processing equipment (He and Tian, 2015; Li et al., 2017; Su et al., 2015). Moreover, our country has introduced a series of policies requiring people to reduce the pollution caused by domestic waste, enhance the recycling and utilization of garbage, and promote the construction of ecological civilization in China. Based on the above analysis and reasons, the effective sorting and collection of the source of urban solid waste and the research on and application of the technology of household waste automatic packaging, compression and classification will bring enormous economic and social value.

## 2 DESIGN SCHEME

### 2.1 Problems and causes of the design of household trash can

(1) There are few shopping bags that match the trash cans on the market, therefore, increasing the

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adaptability of the trash can be a good solution to the problem (Nie and Huang, 2012)

(2) The current garbage cans are designed with only one cylinder. The kind of single-drum refuse bin does not have the function of classification, so the garbage cannot be classified. This shortcoming leads to environmental pollution and serious waste of resources.

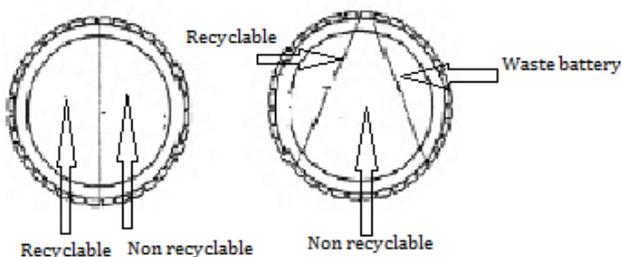
(3) The garbage bag is relatively shallow when it is used in a garbage bin. It easily falls off when it is hung on the garbage can, so that the garbage can't be collected properly. Although there are some garbage cans with ferrule design on the market, which can solve the problem of garbage bags hanging, however, when the garbage bag is too thin or too thick, the rings on the garbage can become loose or refuse to be loaded with garbage bags, so that the garbage bags are unusable. In addition, the design of the garbage can with a ring is a split-type design, and the cost is high, and the ring is easy to be polluted by garbage. (Jin and Liu, 2010)

(4) At present, the household garbage cans on the market have single function or poor adaptability.

**2.2 Design ideas**

Based on the market research and the usage of household garbage cans and a comprehensive institutional analysis, the intelligent trash cans with mechanical system and control system are designed for the family and office use, which can meet the requirements of classification, automatic compression and packing and solve the problem of odor and secondary pollution treatment.

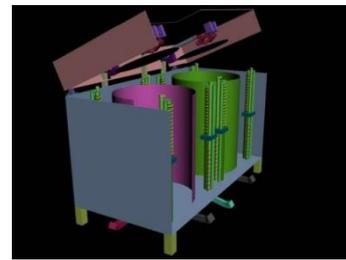
On the basis of traditional dustbin, the multi-opening design is adopted (Zhu, 2013). The bucket mouth area can be divided into two or more sets of blocks to realize garbage classification, as shown in figure 1. Depending on the size of the bag and the user's demand, the bucket area can be divided into other types.



**Figure 1. Bucket mouth structure drawing**

A compression transmission mechanism is designed to compress and reduce the volume of bagged garbage, and an automatic detection system is designed to monitor the height of the garbage bag and finish packaging. The design of a liquid drying

system can reduce the sewage odor, and sporadic outflow. The overall structure is shown in figure 2.



**Figure 2. Whole structure drawing**

**3 WORKING PRINCIPLE AND PERFORMANCE ANALYSIS**

**3.1 To achieve the compression function**

Through the analysis and synthesis of the mechanism (Zheng and Wu, 2008) and the comparison of the schemes, the compression mechanism is optimized.

Plan 1: The automatic trash can use the vertically compressed plate and can be driven either by feet or by a motor drive (Jia and Wang, 2011). The movement of the automatic garbage bin requires the transmission of force along the axis of the barrel. Although the structure is simple, it has an obvious compression effect (Liu and Mao, 2014). The disadvantage of this compression method is that it can easily damage the garbage bags and make the light garbage expand (See figure 3).



**Figure 3. Plan 1**

Plan 2: The transverse extrusion is adopted, and a roller with cutter teeth is installed at the entrance. The pulverized light waste is atomized after entering the garbage bag, so as to reduce the extension of the light garbage, as shown in figure 4. The transverse extrusion can be driven by hands or motor. This method requires a great deal of force transmission, thus a chain drive is more suitable, and it can increase the accommodation space. The transverse extrusion structure is adopted in the design (See figure 5).

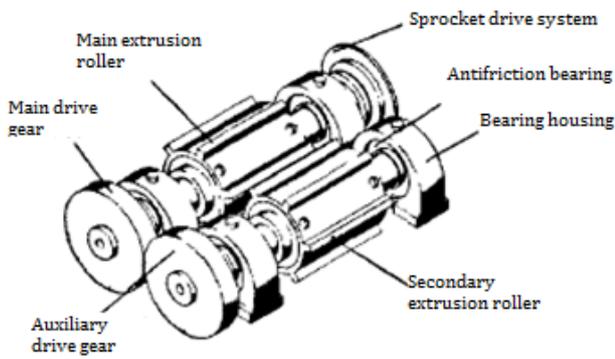


Figure 4. Roller

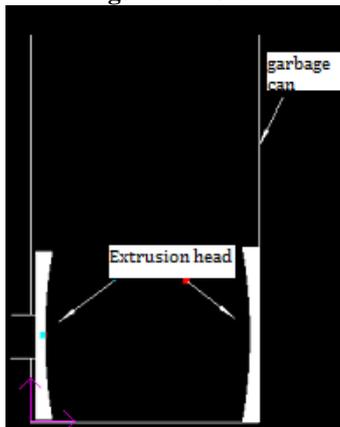


Figure 5. Plan 2

### 3.2 Function of packaging bags

In order to solve the problem of garbage collection from the garbage can, such an automatic packaging structure in the intelligent automatic garbage can is came up with. Users can just take out the garbage when it is packaged, which is convenient and hygienic.

The automated trash can that I studied is a collection of the leverage applications. The overall structure is a square structure with four columns at each angle. The two of the four pillars of the structure are movable and effectively linked. The two pillars can move at each angle and are linked together at the bottom. There is a pedal at the bottom that transfers the force of the feet movement to the eight columns of the linkage. The packaging is realized with elastic force. The rubber band is adhered to the four pillars of the leather rope, and the four fixed columns set a limit block which prevents the rope from being pulled out. When the foot position changes, the leather rope on the rubber band exhibits its tension, thus completing the packing action. In addition, the pillar is covered with many rings to avoid the trouble of bagging every time. Once you run out of it, just take it out. So the other four linkage pillars are to ensure that the second leather cases are not ejected. Likewise, it

is also achieved by a horizontal block. Then, the automatic packaging and multiple packaging are completed.

The bagging design and bagging mechanism need to put a number of garbage bags on the upright post (See figure 6).



Figure 6. Structure drawing of packing bag

### 3.3 Classification function

The bucket mouth area is divided into two or more blocks, so that the garbage classification can be realized. The structure is shown in Figure 1. The bin mainly considers the physical properties of the refuses, and then throws them into different pockets. Press and seal the kitchen waste, and crush the lightweight garbage.

### 3.4 Auxiliary function design

As a new type of product, we shall consider not only its operability, but also the mood of users, thus the convenience of use and the saving of energy are taken into account, and we need to consider adding some user-friendly function designs.

(1) A photosensitive switch is arranged at one end of the automatic waste bin and the input port is close to the compression area. (Huang and Liu, 2014). This photosensitive switch is used to control the running time of the motor. With this method, energy saving can be achieved.

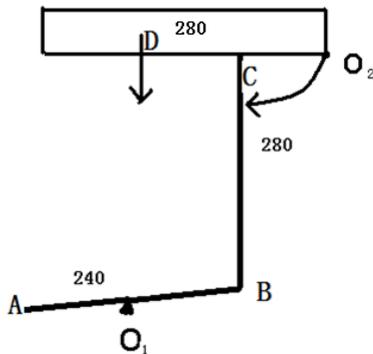
(2) In this automatic waste bin, there is an end cover at the outside of the inlet, which is controlled or closed by the infrared light. The automatic trash can open automatically when someone's hand is near. In this way, the user doesn't need to open the end cap with hand because of the hygiene problem.

(3) There is an interlock circuit between the automatic garbage can, the input terminal, the photosensitive switch and the circuit of the motor. When the end cover of the automatic garbage bin is not closed, the motor will not start, and when the motor starts, the end cover will be opened. In this way, the automatic garbage can safeguard the user's safety and prevents accidents caused by the improper use of the user.

(4) In the circuit of the automatic trash can, insert a sound chip that can make sound. When someone uses this smart, automated garbage can, the sound chip will preach some slogans about protecting the environment and saving resources to encourage people to use the garbage can.

**3.5 Theoretical design calculation**

Flip part (See figure 7):



**Figure 7. Flip link design**

The flip top principle is the usage of two levers, with the quality of 500g. The quality of the foot lever and other connecting rods is negligible. The foot lever  $AO_1=24\text{cm}$ ,  $O_1B=18\text{cm}$ . When the lid is lifted, the foot lever pressure on the pedal is A:

Analysis picture: There are two levers  $AO_1B$  and  $O_2CD$ .  $O_1$  and  $O_2$  are two fulcrums. The size of each power arm and the weight of the lid are known. Use the gravity formula to get the lid weight. The equations of lever balance are used to list the equations, and the pressure of the foot on the A of the pedal is calculated.

The force of the foot on point A is F, the acting force of point B is  $F_1$ , and the acting force of the C point is  $F_2$  According to the lever balance condition, we have:

$$F \times AO_1 = F_1 \times O_1B \tag{1}$$

$$G \times DO_2 = F_2 \times CO_2$$

(2)

$$F_1 = F$$

The weight of the lid:

$$G = mg = 0.5\text{kg} \times 10\text{N/kg} = 5\text{N},$$

The result:

$$\begin{aligned} \therefore F &= O_1B \times DO_2 / CO_2 \times AO_1 \\ &= 100 / 40 \times 10\text{N} = 25\text{N} \end{aligned}$$

The foot pressure on the pedal A is at least 25 N.

Packing part:

The bottom of the four columns is connected by iron plate. When treading a pedal, the minimum

stroke of the column falling simultaneously is 5mm. There is a spring at the bottom to ensure that the upright post can be restored to its original position when the pedal is lowered.

The four outer columns have four inner cores. When treading a pedal, the inner cores fall at the same time, and are connected to a spring post. When treading a pedal, the inner core also falls by 5mm.

The pedal stroke is 10cm, therefore guaranteeing the length. The thickness of the sleeve barrel is 5mm. When the pedal is tread, the column falls at the same time, thus ensuring a smooth packing, as shown in figure 8.



**Figure 8. Trash can**

**4 CIRCUIT DESIGN**

According to the functional design requirements, the design of the control system mechanism is completed.

(1) The automatic garbage can has such functions as opening, compressing, packing, drying and liquid removing. The above functions need to be done in sequence or individually. The costs shall be taken into consideration when all functions are completed. Therefore, in the design of the control system, STC89C52 microcontroller is used to control the operation of each motor. Because of the complex working conditions, the motor used for roller and compression motor is not suitable for the equipment, so the stepping motor with larger power is selected, and others use DC motors.

(2) The power supply adopts 12V DC power supply and the opt coupler is isolated between the microcontroller and the motor drive.

The power supply is the key component to ensure the stable and reliable operation of this intelligent automatic garbage can, and directly affects the performance of the equipment. As for the equipment, the motor drives and controllers use two

power supply with different voltage levels to avoid the interference between the two power supplies. This equipment adopts double power supply system. The power supply of the motor adopts a stable power supply module, and can transform the 220v AC voltage into 24v DC voltage. The operating voltage is 24 V, which can offer a stable current of 6A to the three-step motors. The controller power supply also adopts the small power supply voltage stabilizing module. The input terminal is connected to the 24V voltage output terminal of the first regulated power supply. The output voltage of the output voltage is changed to 5V. The voltage is stabilized by rectification and filtering, and the power is supplied to the microcontroller.

### (3) Infrared induction sensor (HC-SR505 module)

The HC-SR505 small body induction module is an automatic control product based on Infrared Technology, with high sensitivity, strong reliability, small volume and low voltage (Wang, 2011). It is widely used in all kinds of automatic induction electrical equipment, especially in dry cell powered automatic control products. It has the characteristics of fully automatic induction and repeatable triggering. In this kind of classification garbage can, the human induction module is the core chip of the switch module. This module has a large cone angle, standing for wide range of induction. We put the human sensor module just above the garbage can. On the one hand, the induction cone angle is large, to prevent passers-by from reluctant garbage throwing. The garbage can is opened and closed by itself; on the other hand, it can sense the people in surrounding area when it is installed above the garbage. The sensing range is a circle with a garbage bin as the center and a radius of about 1m, which is quite user-friendly.

### (4) Metal sensor (LJ30A3-15-Z/BX proximity switch sensor)

This type of proximity switch is a high frequency oscillation type. It detects signals quickly without contact, pressure or sparks. It is used to drive a relay or logic gate short stroke. The output power is large and the anti-interference performance is sound. The utility model has the advantages of reliable work stability, long service life, and so on. The switch is filled with resin to make it completely closed. It has the characteristics of vibration resistance, corrosion resistance and waterproofing. Capacitance structure is used in metal sensors. When the metal sensor detects the metal, the capacitor changes and the low level is input to the

IO port of the single chip; when the nonmetal is detected, the capacitance is unchanged, and a high level is input to the microcontroller. And then the next step is to combine with the program to decide what do in next.

### (5) Motor drive module (L298N module)

The L298N module is a high-voltage and high-current motor driver chip. (Zhou and Xu, 2006). The chip uses a 15 pin package. The main features are as follows: the working voltage is high, with the maximum working voltage of up to 46V; the output current is large, and the instantaneous peak current is up to 3A; the continuous operating current is 2A and the rated power is 25W. A high-voltage and large-current full bridge driver with two H bridges is used to drive the inductive loads such as DC motors, stepping motors, relays, coils, etc.; the standard logic level signal control; with two enable control terminals, the input signal under whatever condition allows or forbids the device to have a logic input power; the internal logic circuit works under low voltage; the external detecting resistor can be connected to the control circuit by changing the amount of resistance. L298N chip is adopted to drive the motor, which can drive a two-phase stepper motor or a four-phase stepper motor, and can also drive two DC motors. In this smart trash can, the first opening and closing part have the same angle as the opening and closing cover, If the DC motor is used, the motor will be out of control. For example, due to the influence of the gravity of the lid, the speed of the DC motor will slow down due to its overcoming the gravity work when the DC motor is opened; while closing the lid relying on gravity, and doing positive work will speed up the closure. In the long run, the error will be larger and larger. By doing so, the rotation angle can be controlled by the step motor, so the lid opening and closing angle must be the same, so that there will be no DC motor errors.

## 5 SOFTWARE PROGRAMING

This design uses the C language programming in the Keli environment, and the main program block diagram is shown in the figure. The software programming is to achieve infrared induction, metal detection, motor drive, speed control and other functions. The main software flowchart of the control section is shown in figure 9, which writes the program in accordance with this process.

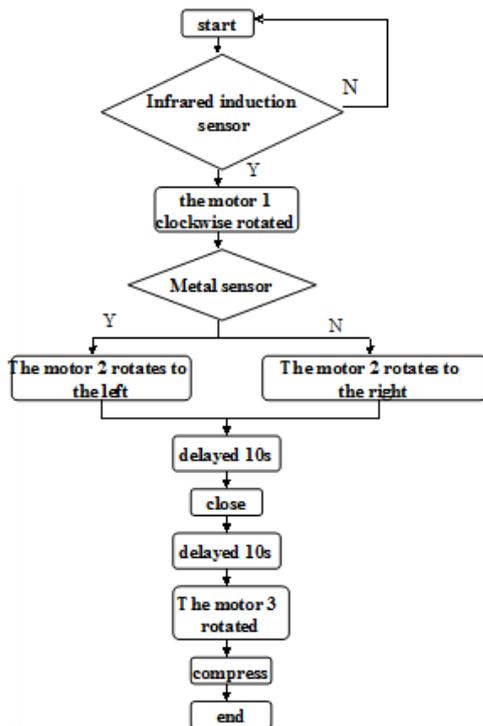


Figure 9. The main software flowchart of the control section

## 6 CONCLUSION

The designed structure is simple with perfect transmission performance and sound compression effect, which can meet the requirements of domestic waste treatment. This new garbage classification, compression and packaging equipment meets the requirement of household waste treatment. It not only can be used in ordinary families, but solves the problem of garbage bags packing and other similar troubles in daily life. It also improves the efficiency of all sanitation workers and reduces their workload, while beautifying our common social environment. It can also reduce the white pollution. The automatic trash can be used in restaurants, hospitals and other public places requiring special packing and handling of rubbish. The use of the automatic waste bin can avoid heavy pollution, and has fairly high application value.

## 7 ACKNOWLEDGEMENTS

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