

## Research Article

### Design and Research on Auto-vending Machine for Cupped Beverage

Xiaowei Jiang and Yonghong Sun  
Changchun University, Changchun 130022, China

**Abstract:** The aim of this research is to design an auto-vending machine for cupped beverage, specifically researching its working principle, the design of beverage powder transporting mechanism, paper cups detaching mechanism and paper cups slide mechanism. The article elaborates that the design of beverage powder transporting mechanism is mainly the selection of electromagnet and the determination of electromagnet stroke, requiring that the electromagnet stroke and the maximum weight that the electromagnet could bear should have rationality, to ensure its safe operation; the design of paper cups detaching mechanism mainly includes selecting electric motor and V belt; the design of paper cups slide mechanism includes the design of slide structure and the force analysis when the paper cup slides on the slide. And then the working principle and working process of the auto-vending machine for cupped beverage is introduced, based on which the conclusion has been reached.

**Keywords:** Auto-vending machine, cupped beverage, detaching mechanism, slide mechanism, transporting mechanism

#### INTRODUCTION

The auto-vending machine is not restricted within some place, conveniently and quickly. It could sell goods 24 h every day, so it is popular with office workers. Many offices of company are placed auto-vending machines, selling all kinds of goods, from drinks, snacks, cigarettes, candy to the toothbrush and instant noodles. In Japan it even uses the auto-vending machine sell rice, oil and underwear. This way of avant-garde retail has appeared in 65 countries and regions. The auto-vending machine is very popular in developed countries. In Japan, it has 1 million auto-vending machines only in Tokyo and In the whole Japan it has a total of 6 million auto-vending machines of various types, having 1 per 23 people, having 1 per 40 people in the United States and having 1 per 60 people in Europe (Pei, 2003). The development and social ownership of auto-vending machine has become an important symbol of measuring the degree of city modernization and civilization level (Jiang, 2014).

While at abroad it is the beverage manufacturers that guide, lead to the development of auto-vending machine, in domestic the situation is on the contrary, as beverage manufacturers are not interested in this kind of business operation style, so the machine manufacturers have to seek the middle enterprises, with the machine, seeking exit. Since 1992, the auto-vending machine was put into production in domestic, of which the market growth is very slow.

At present, the domestic auto-vending machines have two major classes, namely the completely

independent development class and the agent sales abroad class. Among them, the price of the auto-vending machine made in our country is focused on the 30000 yuan to 40000 yuan and the price of the agent abroad class auto-vending machine is about 50000 yuan (Pei, 2003).

The product type of auto-vending machine includes the auto-vending machine for cold drink, auto-vending machine for hot drink, auto-vending machine for goods, auto-vending machine for cigarette and other types. The mode of payment of auto-vending machine mainly adopts the cash settlement way, namely in cash COINS or paper money (Zhan, 1987).

At present, in domestic there have been many manufacturers having the capacity of developing and producing auto-vending machine. The domestic manufacturers of auto-vending machine are distributed in different areas, some having been in the stage of product promotion and some being in the stage of investment promotion. At present, due to various reasons, the market promotion of auto-vending machine is slow and there is no better business model. The market of auto-vending machine is in the stage of cultivation (Jiang, 2013). The products produced by the domestic manufacturers of auto-vending machine are mainly the auto-vending machines for cold (hot) drinks, foods, cigarettes and other products (Pei, 2003).

The purpose of this research is to design an auto-vending machine for cupped beverage, specifically researching its working principle, the design of beverage powder transporting mechanism, paper cups detaching mechanism and paper cups slide mechanism.

Table 1: Technical parameters of the selected electromagnet

Model No.	Using manner	Rated attraction (kg)	Rated stroke (mm)	Electrifying sustained rate (%)	Operation frequency (time/h)	Weight (kg)	Total weight (kg)
Mq1-15L	Pull manner	15	50	60	200	2.3	9.00

**DESIGN METHODS**

**Design of beverage powder transporting mechanism:** Beverage powder transporting mechanism mainly takes advantage of the magnetic characteristics of electromagnet to send the powder to the specified location. The powder drops to the blender under its own gravity and eventually flows into the cup. The essential parts of the mechanism are made up of electromagnet, powder barrels, slider and others, of which the main characteristic is that the transportation is smooth and accurate, the structure is tight and the leakproofness is good. The central part of slider is designed according to the appropriate volume of powder.

- **Selection of electromagnet:** It's a good choice to use MQ1 series pull electromagnet according to the mechanism character. According to design it is known that the centre line distance between the hopper and the leaking hole designed is 54. It is finally determined to choice the electromagnet of 50 mm stroke according to the Mechanical Design Manual (Cai, 1993). Calculation of the quality M of middle slider:

$$L = 198 \text{ mm } B = 70 \text{ mm } H = 20 \text{ mm}$$

$$V = LBH = 198 \times 70 \times 20$$

$$= 277200 \text{ mm}^3 = 0.0002772 \text{ m}^3 \quad (1)$$

$$M = \rho \times V = 7.8 \times 10^3 \times 0.0002772 = 2.162 \text{ Kg} \quad (2)$$

The Table 1 is the reference datum of the selected electromagnet.

- **Structure design of beverage powder transporting mechanism:** The following figure is the three views of beverage powder transporting mechanism, in which the size of each parts is designed according to the space size of the auto-vending machine for cupped beverage, as shown in Fig. 1 to 3.

From above figures it could be clearly seen that the electromagnet stroke could ensure the aligning of filling powder mouth of slider by pulling slider 2 with electromagnet 1 to move back and forth, so as to ensure that beverage powder could entirely flow into the cup.

**Design of paper cups detaching mechanism:** Paper cups detaching mechanism is the main constituent part of the auto-vending machine for cupped beverage, which is made up of an electric motor, a pair of outer

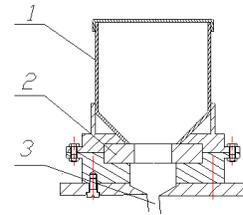


Fig. 1: Main view of beverage powder transporting mechanism; 1: Plastic barrel; 2: Slider; 3: Plastic pipe

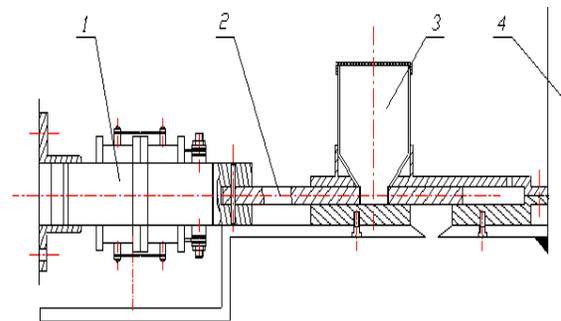


Fig. 2: Side view of beverage powder transporting mechanism; 1: Electromagnet; 2: Slider; 3: Plastic barrel; 4: Machine well

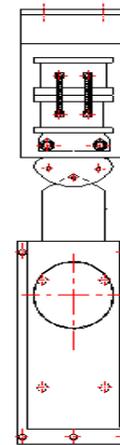


Fig. 3: Depression view of beverage powder transporting mechanism

occlusive gears, inner occlusive gears and specific gears. It drives initiative wheel with electric motor and drives driven shaft to turn, making paper cup detach (Li, 2005).

- **Selection of an electromotor:** Electromotor could be divided into synchronous electromotor, continuous current electromotor, asynchronous

electromotor and others. As the output power of the structure is small and requiring stable and accurate work, it should adopt TYV series high-precision miniature reduction continuous current electromotor.

- **Selection of V belt:** Known:  $P = 0.37 \text{ KW}$   
 $n_1 = 25 \text{ r/min}$
- **Calculating the power:** According to the Mechanical Design Manual, it is determined the work coefficient  $K_A = 1.0$ , so

$$p_d = k_A = 1.0 \times 0.37 = 0.37 \text{ kw} \quad (3)$$

- **Selecting the narrow V belt type:** According to the power calculation,  $p_d = 0.37 \text{ kw}$  and truckle  $n_1 = 25 \text{ r/min}$   
According to the Mechanical Design Manual, it is determined to choice the SPZ type.
- **Calculating the datum diameter of pulley:** As the size of paper cup has been determined and other space is also limited, rotational speed of pinion is 30/min.

**Design of paper cups slideway mechanism:** This design requires that after detached by paper cups detaching mechanism, paper cup could be accurately sent to appointed position. Mechanism liking this has a lot, such as the mechanical hand and others, but this design adopts the slideway mechanism that is not only simple but also accurate to deliver paper cup. The paper cup will slip on the smooth orbit to appointed position after falling. This mechanism requests material have good and smooth character to promise the paper cup smoothly to slip to bottom, so this slideway adopts the stainless steel as material. While designing it should ensure the slideway size corresponds to the size of paper cup, thus promising that it is unlikely for paper cup to be blocked in the process of moving downward:

- **Structure design of slideway:** This structure design of slideway is simple and reasonable, which could accurately send paper cup to appointed position, as shown in Fig. 4 and 5.
- **Force analysis when paper cup sliding on slideway:** As existing friction between the slideway and the paper cup, it need to compute whether the paper cup could slide to the appointed position smoothly.

The material of slideway is stainless steel and the material of paper cup is general hard paper, so through checking the manual, it gains the friction coefficient between the slideway and the paper cup  $\mu = 0.2$ .

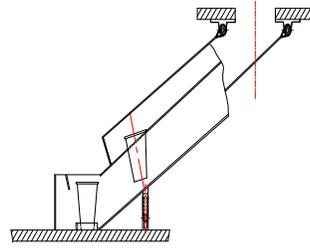


Fig. 4: Main view of slideway

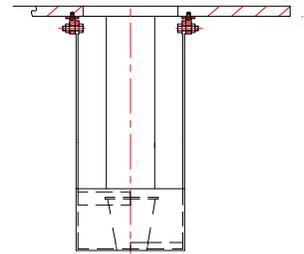


Fig. 5: Right view of slideway

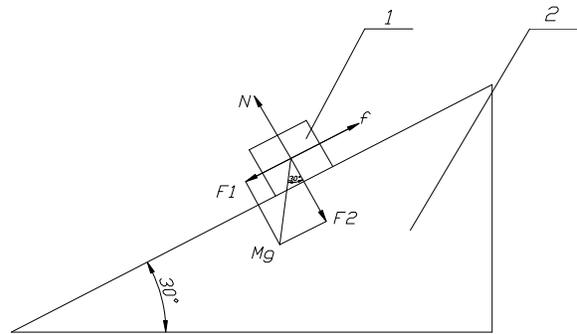


Fig. 6: Sketch map of force analysis of paper cup; 1: paper cup; 2: slideway; N: support force of slideway giving paper cup; f: friction force between slideway and paper cup; Mg: weight of paper cup;  $F_1$ ,  $F_2$ : two component of force of paper cup gravity

The force analysis when paper cup sliding on slideway is shown in Fig. 6:

$$\text{By } N = F_2 = Mg \cos 30^\circ \quad f = \mu F_2 = \mu Mg \cos 30^\circ$$

$$F_1 = Mg \sin 30^\circ$$

$$\text{Having Newton second law: } F_1 - f = Ma$$

Namely

$$Mg \sin 30^\circ - \mu Mg \cos 30^\circ = Ma$$

$$0.5g - \frac{\sqrt{3}}{2}g\mu = a$$

$$0.5 \times 10 - \frac{\sqrt{3}}{2} \times 10 \times 0.2 = a$$

(4)

$$\text{Calculated } a = 3.268$$

It could be seen from the calculation result that the paper cup could accelerate to move along slideway

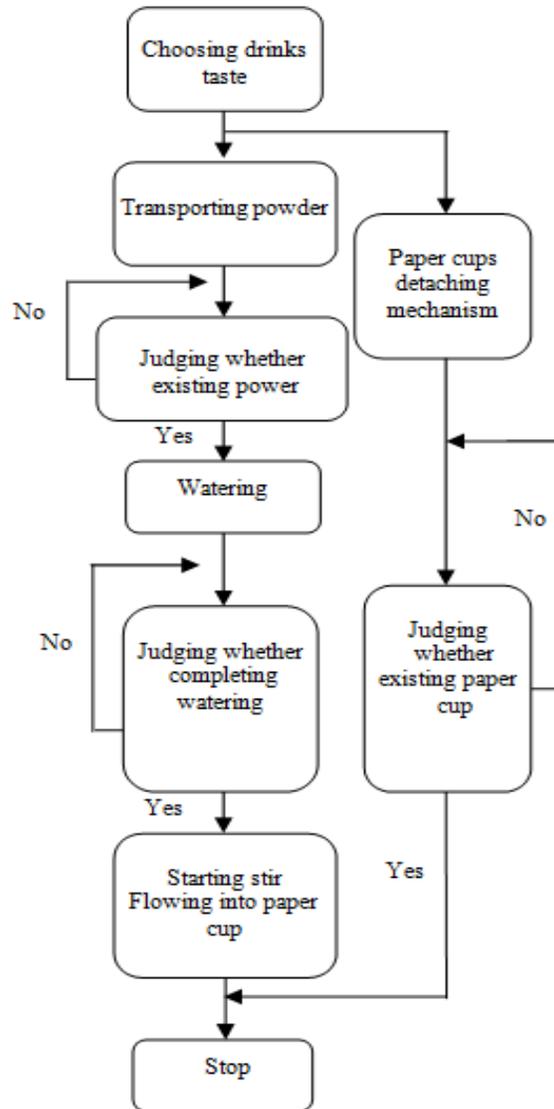


Fig. 7: Workflow chart of the auto-vending machine for cupped beverage

downward, so the paper cup could smoothly slide to appointed position.

This mechanism still has the function of regulating the inclination angle of slideway, so it could slide to bottom with more than 30° inclination angle, which increases another insurance for paper cup to slide to bottom smoothly.

### WORKING PRINCIPLE AND WORKING PROCESS

**Working principle:** The work principle of the auto-vending machine for cupped beverage is that customers need to throw coin or banknote of corresponding face value, if having not banknote of corresponding face value, it could throw the banknote of bigger face value and the machine will return change automatically. Of

course, it also could brush card (Zhu and Wang, 1995). Then choosing the beverage and pressing the homologous button, the sensing system will deliver the signal to the paper cups detaching mechanism, of which the electromotor begins to work after receiving the signal, thereby separating paper cup and then sending to appointed position by the paper cups slideway mechanism. At the same time, the powder mechanism also receives the signal, provides hot water or cold water toward the mixer according to the request of customers, conducts stir, finally flows into the cup and completes the work.

**Working process:** According to the work sequence of the auto-vending machine for cupped beverage drawing up the flow chart, as shown in Fig. 7.

It could be seen from the workflow chart that after choosing beverage, the transporting powder mechanism and the paper cups detaching mechanism receive the signal in the meantime and begin to work. After the transporting powder mechanism completes the work, it starts to inject water after judgment and then to stir. At the same time, the transporting cup mechanism sends the paper cup to the appointed position and finally opening the mixer valve, the beverage flows into paper cup. If above judgment is “no”, it will make circulating judgment. If more than three times, it will be invalid. After nullity, it will automatically deliver the signal to the worker, who will make the homologous maintaining.

### CONCLUSION

- The auto-vending machine for cupped beverage is easy to install, repair and replace spare parts. The design is in accordance with principles of ergonomics and it is convenient to operate and safe and reliable to use.
- The overall structure of the auto-vending machine for cupped beverage is concise and reasonable.
- The manufacturing technical requirement and manufacturing cost of the auto-vending machine for cupped beverage is low and the standard parts are plenty, so general machinery factories could make by themselves.
- Having the function of automatically controlling the concentration of beverage and others.

### ACKNOWLEDGMENT

This research is supported by the General-planning Subject of the Twelfth Five-Year Plan of Educational Science of Jilin Province under the grant No. GH14243 and the Teaching Research Subject of Changchun University under the grant No. XJYB14-02.

**REFERENCES**

- Cai, C., 1993. Mechanical Design Manual. Liaoning Science and Technology Press, Shenyang, pp: 135-140.
- Jiang, X., 2013. Design and application on mini type food slicer. *Adv. J. Food Sci. Technol.*, 5(10): 1322-1324.
- Jiang, X., 2014. Development design of new age food machinery. *Adv. J. Food Sci. Technol.*, 6(1): 140-143.
- Li, Y., 2005. Study on the mechanism of ring-pull can coming out of auto-vending machine. *Mech. Electr. Technol.*, 2: 32-36.
- Pei, J., 2003. Development of a new type auto-vending machine. *Sci. Technol. Inform. Dev. Econ.*, 13(12): 141-142.
- Zhan, Q., 1987. Automatic Mechanical Design. China Light Industry Press, Beijing, pp: 154-162.
- Zhu, J. and H. Wang, 1995. Application of microcomputer in the auto-vending machine. *Market Moderniz.*, 11: 45-47.