PAPER • OPEN ACCESS

Design and Analysis of Sorting Structure of Special-shaped Cigarette

To cite this article: Xudong Yang *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **493** 012073

View the article online for updates and enhancements.

Design and Analysis of Sorting Structure of Special-shaped Cigarette

Xudong Yang [1], Kangqi Mu [1, *], Junhua Zhang [2] and Dong Sun [3]

[1] College of Mechanical Engineering, Guizhou University, Guiyang, China
[2] Guizhou Machinery and Electronic Products Quality Supervision and Inspection Institute, Guiyang, China
[3] College of Mechanical Engineering, Guizhou institute of technology, Guiyang, China

* Corresponding author e-mail:1147834557@qq.com

Abstract. Aiming at the characteristics of cigarette logistics distribution center, the low degree of automation of the special-shaped cigarette sorting equipment, low work efficiency, which is not easy to implement automatic management, a sorting actuator of pinch-type is designed for special-shaped cigarette. Considering the special attributes of multi-size, multi-shape, and multi-specification of the special-shaped smoke, to improve the efficiency of sorting equipment, the team designed a flexible high-density cache warehouse. a set of appropriate sorting execution strategy is proposed. The design of the mechanical structure is simple, real time control of sorting process. Through the experiment, the design feasibility of the mechanism is verified. It provides a theoretical basis for the design improvement of the follow-up equipment.

1. Introduction

In recent years, with the increasing sales of special-shaped cigarette, the sorting and packaging work of special-shaped cigarette has puzzled China's tobacco distribution center for its development bottleneck. Since the shaped smoke cannot be sorted at the distribution center using rigid equipment like standard smoke. In most cases, electronic tag-assisted manual sorting can only be used [1] aking it difficult to realize the automation of heterogeneous cigarette sorting and packaging on a large scale. Figure 1 is the sorting process.

However, increasing the labor cost to complete the growing workload of shaped cigarettes, apparently, inconsistent with the development needs. According to the statistics, cigarette distribution center's special-shaped tobacco sorting workload accounts for 60% of the entire distribution workload, sorting costs account for 40% of the total delivery cost [2]. As for this, a sorting actuator of pinch-type is designed for special-shaped cigarette. the purpose is that the distribution center sorts the cigarettes of various brands one by one after receiving the orders. It is gradually transferred to the follow-up workbench in the form of orders to ensure the completion of the follow-up work and provide security for the automatic sorting of the set of special-shaped cigarette streamlines. Simultaneously, put forward a set of sorting and execution strategies applicable to the equipment to ensure that the orders can be sorted according to requirements before entering the sorting system to avoid sorting confusion, and design a high-density sorting cache for smoke bins to ensure efficient operation of sorting while maximizing the space occupied by sorting equipment. As shown in figure 2.
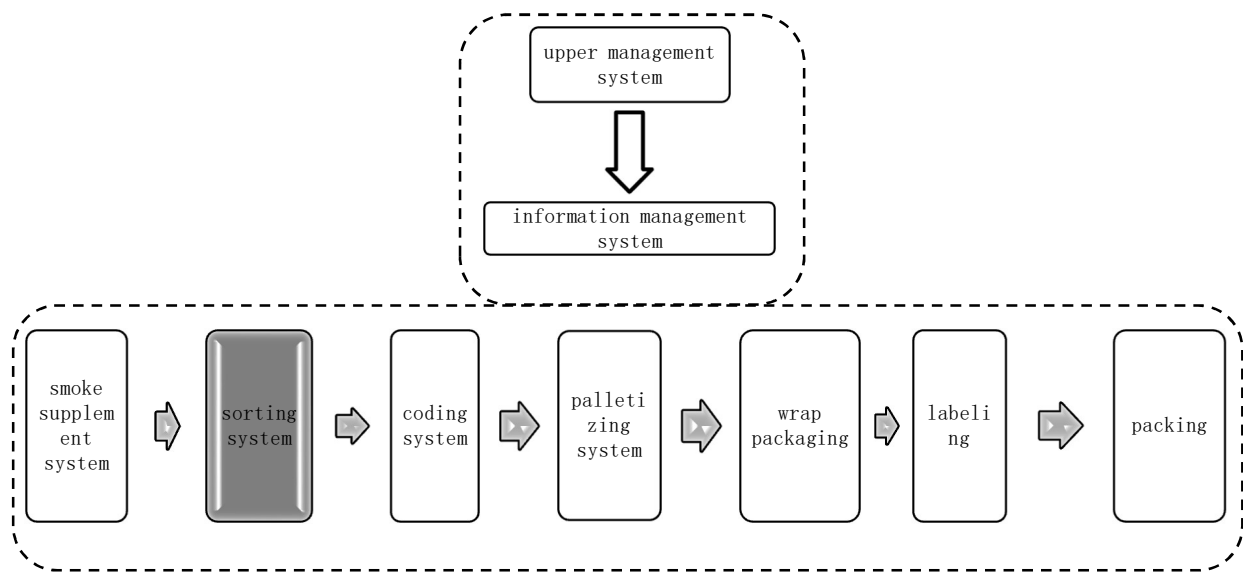
Figure 1. Order processing process

2. Sorting and smoke extraction mechanism design

The construction of the load-bearing rack for sorting equipment is a construction combination of industrial aluminum profiles. Using SW to Establish Three-dimensional Models for Differentiated Smoke Sorting Mechanisms, as shown in figure 3.

1.Clamping shaft 2. Support plate 3. Rotating shaft 4. Pulley 5. Photoelectric Sensors
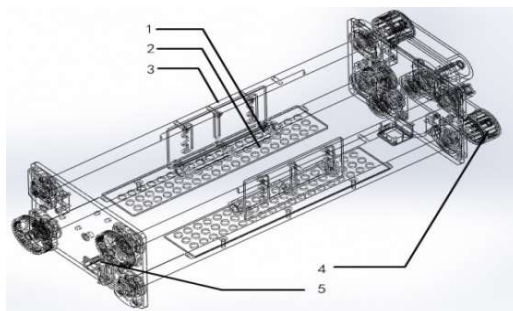
Figure 2. special-shaped cigarette sorting line   **Figure 3.** sorting actuator of pinch-type

The support plate 2 is fixed on the rotating shaft 3 connecting to the shaft in a plane fit, Connect the pinch shafts 1 on the sides of the double side plates, and connecting the pinch shafts 1 on the sides of the double side plates. Considering the possibility of smoke-like damage on the side of the bar, A flexible clamping device is arranged on the outer surface of the clamping shaft, and a high-density sponge is used as a sleeve. One part, the gripping force of the clamping shaft is increased. the other part, the destruction of the side of the cigarette is avoided because of the rigidity of the clamping shaft 1 when the cigarette is clamped. The support plate mechanism is designed at an appropriate height on the underside of the splint, and the rotation of the connecting shaft is adopted. The rotation of the shaft drives the support plate to turn over, and the support plate rotates around the axis.

The rotation of the shaft adopts the power input of the outer gear meshing with the timing belt. In order to realize the synchronous action of the splint or the support plate, a synchronous belt wheel transmission method is adopted between the parallel axes in the horizontal direction to ensure the rotation of the shaft rotation. On the shaft of the lower side support plate, synchronous belt drive is also

used to achieve parallel rotation of the shaft. An independent servo motor is used for the power input between the upper and lower axes to achieve precise control of cigarette sorting.

When the cigarettes are sorted, the two-axis rotating mechanical action is used to drive the cooperative movement of the plywood support plates, and finally the sorting of the cigarettes from the independent flexible smoke bin to the drive belt is finally achieved.

3. Flexible smoke chamber design

In order to adapt to the diversity of the appearance size of the shaped smoke, ensure that the cigarettes can be automatically sorted out of the warehouse according to the order after being placed in the smoke warehouse, and equipped with a set of flexible adjustable smoke chamber components. The set of components can utilize the mechanical structure to achieve the adaptive adjustment of the up, down, left, and right sides of the smoke bin, so as to satisfy the temporary storage of smoke bins of multiple types of cigarettes. The adjustable smoke bin design adopts the combination of left, right, and rear baffle design. The right and left side baffles adjust the width of the baffle by adopting the adjustment method of the long screw on the back. As shown in figure 4.
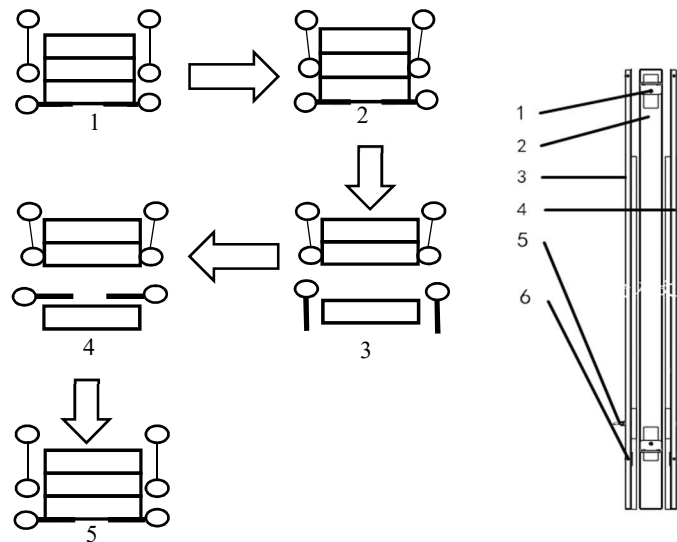
1. Backsplash adjustment bolt 2. Tailgate 3. Side baffle 4. Side baffle adjustment bolt 5. Photoelectric switch

Figure 4. Flexible smoke chamber   **Figure 5.** Sorting action process

The long screw is fixed on the two side baffles, the other end is fixed on the frame, and the distance adjustment of the baffles on both sides is realized by thread rotation so as to meet the adaptability of different widths of the cigarettes. In order to achieve accurate sorting of cigarettes, the remaining cigarettes in the cigarette holders are fed back to the system in time to confirm whether the sorting task can be continued. A photoelectric detecting device 6 is arranged at a certain height position of the side baffle from the bottom of the baffle to detect the number of remaining cigarettes in the smoke chamber. Simultaneously, we set the minimum number of cigarettes and supplement it in time to ensure the smooth operation of sorting operations.

4. Order processing

Processing of sort orders is based on a sorting information management system. After receiving the order information of the upper sales order system, the sorting information management system reorganizes the data according to related strategies, and performs data processing in the optimal manner

of sorting efficiency, then generate control instructions through the monitoring system, with the assistance of the staff, the system can automatically complete the different types of cigarettes such as smoke, order splits, order consolidation, order packaging and other tasks. And realize sorting to household within the specified time and temporarily exist in the corresponding area for loading and distribution.

Sorting orders are obtained from the upper information system. After the current visit and purchase data obtained from the upper information system, follow the sorting execution strategy to optimize. The data obtained from the upper-level information system includes the distribution line basic data, cigarette basic data, customer base data, and visit-sale order data, providing the data foundation for the operation plan, and then determing the sorting positions that each cigarette should use, that is, the distribution of sorting smoke positions. Determine the cigarette brands that the sorting line occupies, respectively, according to the distribution of sorting smoke bins, then carry out order optimization to determine the quantity of each order sorted in the corresponding sorting warehouse. The distribution of cigarette brands occupying two or more sorting bins is based on the principle of total balance. Finally, verify the optimization results. For example, distribution line data validation, order data validation, cigarette category validation, etc. After the data verification is correct, the system prompts the information to be sent successfully and sorting can be started. After manually issuing the sorting instruction, the sorting control system instructs the sorting execution system to start to sort. After the sorting task is released, the data is loaded into the upper computer. The upper computer processes the data and sends it to the PLC. The PLC controls the sorter's position to emit smoke according to the position of the main line encoder. The operating status of the equipment is displayed on the touch screen in real time, and the equipment can be operated and modified by the touch screen.

When the failure of the lower-level equipment occurs, the fault signal is transmitted to the PLC by the upper computer. When the PLC responds to the fault information, the sorting stops immediately. And Fault information real-time display assisted manual exclusion. Considering the convenience of distribution, the upper management system will sort the required sort orders according to the distribution route, that is, the criteria of "send first and then sort" along the routes along the route [3]. The sorting control system divides and calculates the sorting tasks of the accepted orders to ensure the smooth progress of the sorting procedure. The strategy of sorting out cigarettes is also the core of the research of this topic. As shown in Figure 1.

5. Sorting action process planning

When the order is issued to the sorting system, the sorting system will again divide the unit of the conveyor belt for the sorting equipment according to the sorting order indicated by the upper system. Combining the subsequent stacking methods [4] and controlling the actions of the smoke extraction mechanism to complete the orderly sorting of cigarettes. The operation flow of the smoke extraction mechanism is divided into 5 stages, as shown in Figure 5.

In order to ensure the accuracy of the fall of the cigarettes, the information is fed back to the sorting control system in a timely manner. The photoelectric on-off switch is installed on the underside of the support plate to check whether the cigarettes are sorted out.

Smoke sorting efficiency is the sorting speed of tobacco to be sorted after passing through the flexible smoke bin, which basically reaches 5000 bar/h. Affected by the number of orders, the order rate is more than 1,000, and the sorting rate is more easily guaranteed. System operating efficiency is considered as an artificial supplement to specific smoke. To a certain extent, the sorting efficiency of the system is slowed down, and the speed is slightly lower than the sorting efficiency of the smoke bin. The level of system operation efficiency is related to the manual sorting of specific smoke. The overall system efficiency is the overall operating speed considering the artificial downtime. The sorting rate is shown in Table 1.

6. Rotating shaft static analysis

The flexible smoke bin design provides a buffer base for the cigarettes of different items and also saves a lot of plant area. The height of the single bin design determines the capacity of the cigarettes in a single bin. However, the single-bin cigarette capacity puts forward higher requirements on the torsional strength of the shaft [5].

From the perspective of effect, during the execution of the action of sorting cigarettes, the pinch shaft shall ensure that the cigarettes and the cigarettes above are stationary and do not fall off. The friction force of the high-density sponge and the tobacco bar coat on the pinch shaft balances the gravity of the cigarettes to be sorted and the cigarettes are not damaged. The force diagram is shown in Figure 6.
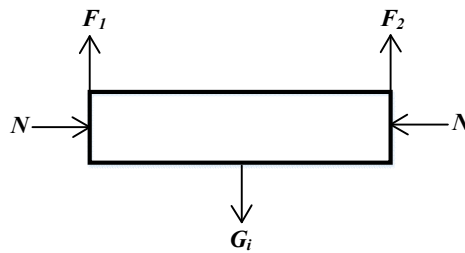
Figure 6. Cigarette Schematic

The static equation is:

$$G_i + F_i = 0 \tag{1}$$

i is a cache of cigarettes and takes the value $1, 2 \cdots 40$. G_i is the weight of the tobacco to be sorted. F_i is the friction force applied by the clamp shaft to the cigarette.

$$F = \mu N \tag{2}$$

μ is the static friction coefficient between the high-density sponge and the cigarette protection film. N is the positive pressure exerted by the clamp shaft on the cigarette.

For torque:

$$M = N_1 R \tag{3}$$

M is the driving force, R is the radius of rotation, N_1 is the positive driving force.

$$N_1 = N \cos \theta \tag{4}$$

θ is the angle between N_1 and the horizontal plane.

After tests, the expected sorting effect was achieved. As shown in Figure 6, the sorting distance between the cigarettes was appropriate. Table 1 shows the data of 10 orders collected during on-site trial operation. The performance of the sorting system was tested from the three perspectives of sorting efficiency, system operating efficiency, and system comprehensive operating efficiency.

Table 1. Test Data

Experimental sample	Order number	Sorting efficiency (bar/h)	System operating efficiency (bar/h)	Overall system efficiency (bar/h)
1	482	8820	8102	7250
2	552	8215	8123	7520
3	998	8652	8452	8102
4	3125	8712	8578	8102
5	703	7035	7152	6412
6	508	8215	8120	7521
7	2115	9005	8820	8021
8	356	8852	8102	7518
9	265	8721	8512	8182
10	525	8820	8125	8205

7. Conclusion

This paper introduces the design of smoke extraction mechanism and the related calculation of statics based on the sorting and sorting system based on heterogeneous smoke sorting system. Discusses the design and analysis of the clamped smoke extraction mechanism, and a design model for flexible cache smokebox is given. The analysis further demonstrates the rationality of the design and provides theoretical support for further improvement of equipment. Project achievements have been successfully applied in Bijie City Tobacco Logistics Center, the reliability of key parts was tested through experiments and on-site commissioning, which provided a reliable theoretical basis for future structural optimization.

References

[1]   Zhang Yuming, Cai Weide, Liu Zhimin et al.Design and Application of a semia-utomatic sorting system for combined s-pecialshaped smoke; 2016,21(4):136-141.
[2]   Wu Susu. The optimization of the order batching and replenishment route about a distribution center of company. Hunan University, 2016.
[3]   LI Shizhen,WANG Changjian. A Optimal Method of Finding Routing Orderpickers in DistributionCenters Using Dynamic Programming Operations Research and Management Science,1997,(8):14-18.
[4]   Chen Fazhong, Yang Xudong, Dong Weifu et al. The control method and system of a smoke stack, CN201610883605.9.
[5]   Wang Changke,Yang Guangwu,Zhu Tao, et al. Sensitivity Analysis of CarBody Torsional Vibration.. Machinery design & manufacture,2017(10):81-84.