Sensors and Materials, Vol. 34, No. 7 (2022) 2517–2522
MYU Tokyo

S & M 2987

Design of Feeding System of Automatic Rod Packing Machine

Chien-Yu Lu,[1] Hsiu-Ying Hsieh,[1] Chun-Liang Tung,[2]
Hui-Fen Wu,[1] I-Chiang Yang,[1] and Te-Jen Su[3,4*]

[1]Department of Industrial Education and Technology, National Changhua University of Education, Changhua City 500, Taiwan, ROC
[2]Department of Information Management, National Chin-Yi University of Technology, Taichung City 411030, Taiwan, ROC
[3]Department of Electronic Engineering, National Kaohsiung University of Science and Technology, Kaohsiung City 807618, Taiwan, ROC
[4]School of Dentistry, Kaohsiung Medical University, No. 100, Shih-Chuan 1st Road, Sanmin Dist., Kaohsiung City 80708, Taiwan, ROC

(Received December 30, 2021; accepted April 26, 2022; online published May 23, 2022)

Keywords: automatic rod packing machine, four-bar linkage mechanism, feeding system

The main objective of this study is to improve the feeding system of a machine for automatically packing rod-shaped objects such as chopsticks. The automatic rod packing machine uses a motor to drive a four-bar linkage mechanism to achieve automatic feeding, but this feeding system can cause noise, and the operation process requires a large torque to prevent components from jamming in the storage box. Thus, the internal mechanism is susceptible to damage by stress, and the adjustment of the machine is very complicated when the damaged components are renewed. To overcome this shortcoming, the feeding system of a conventional machine for automatically packing rod-shaped objects such as chopsticks is first drawn in a 3D diagram. Then, the proposed feeding system of the machine tool, which includes motors, lead screws, and linear bearings, is used to replace the four-bar linkage mechanism of the conventional automatic rod packing machine feeding system to reduce the noise generated by the mechanism when transporting materials and to reduce the damage of the internal mechanism due to stress, and thus the frequency of parts replacement. This design is equipped with two storage boxes and improves the feeding efficiency, the feeding system is made of sheet metal and is combined with motors, lead screws, and linear bearings, and its motion is tested to complete the development and design of the feeding system of the improved machine for automatically packing rod-shaped objects such as chopsticks.

1. Introduction

In recent years, with the rapid development of Industry 4.0, factory production lines have gradually become automated and intelligent. A faster and hygienic packaging of disposable tableware without increasing labor costs[(1)] is a very important issue. Thirty years ago, disposable chopsticks were manually packaged, which was unsanitary and required a lot of labor.

*Corresponding author: e-mail: sutj@nkust.edu.tw
https://doi.org/10.18494/SAM3824

ISSN 0914-4935

Disposable chopsticks are now usually packaged by a machine that automatically packs rod-shaped objects such as chopsticks, as well as straws and bamboo sticks.[2] Such a machine can rapidly print, fill, package, and record, reducing the amount of printed packaging paper needed in the inventory and reducing costs. Moreover, because sterilizing disposable chopsticks with UV or at a high temperature before packaging reduces the problem of mold on the chopsticks sealed in plastic bags, people can use disposable chopsticks with more peace of mind.

The feeding system of the conventional machine for automatically packing rod-shaped objects such as chopsticks is composed of a simple four-bar linkage mechanism with a shift wheel outside the storage box for automatic feeding.[3] The storage box includes a device to prevent chopsticks from jamming, which is required because the cross-sectional shape of the chopsticks makes them prone to jamming. When the chopsticks are fed, they enter the discharge mechanism after passing through the storage box. As shown in Fig. 1, the device that prevents jamming is composed of ratchets driven by a motor, with the number of ratchets (usually two or three) depending on the model of the feeding mechanism. When the machine is running, the motor drives the rotation of each ratchet. The rotating ratchets drive the chopsticks to near the exit of the machine to maintain a smooth feeding state, thereby preventing them from jamming in front of the exit. The discharge mechanism consists of a motor driven cam followed by a four-bar linkage mechanism. As shown in Fig. 1, when discharging chopsticks, the four-bar linkage mechanism drives the clamping jaws. The clamping jaws are released, releasing the chopsticks so that they fall into the packaging. A paper strip is then pushed into the roller by a push rod to seal and cut the film, which completes the packaging action. A power device mainly drives the device that prevents jamming and the discharge mechanism. Its structure is divided into two parts. One part uses a belt pulley to drive the chopsticks to the rotating device and the other uses a cam to drive a four-bar linkage mechanism to discharge the chopsticks. The automatic packaging industry has mainly developed customized automatic packing machines, for example, to package wood into small boxes.[4] Gupta and Kamboj[5] developed an automatic machine for packaging cartons. Fathahillah *et al.*[6] proposed automatic sorting and packaging machines based on color detection. Bansode *et al.*[7] proposed an automatic glass bottle packaging machine. However, no studies have proposed the design of a more advanced machine for automatically packing rod-shaped objects, such as chopsticks, with a feeding mechanism; thus, this paper fills a gap in the literature.

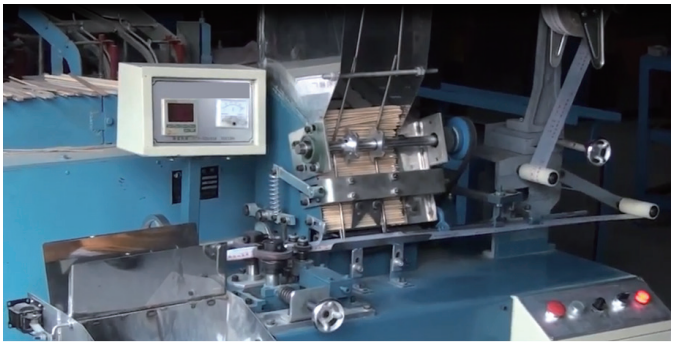

Fig. 1. (Color online) Automatic printing and packing machine for rod-shaped objects.

Therefore, in this study, we use the feeding system of the machine tool to improve the four-bar feeding system of the automatic rod printing and packing machine, which can not only be used for the packaging of chopsticks, but also can be expanded to packing machines using rod-shaped materials, which can reduce the safety problems of personnel engaged in this industry.

2. Design of Mechanism

The machine for automatically packing rod-shaped objects such as chopsticks uses a motor to drive a four-bar linkage mechanism to achieve automatic feeding, but such a feeding system is prone to noise and requires a large torque during operation to prevent the conveyed materials from jamming in the storage box. Therefore, the internal mechanism is easily damaged by stress and is complicated to adjust when replacing damaged parts. On the basis of the above-mentioned shortcomings of the feeding system of such a packing machine, we propose an improved feeding system for the machine.

To improve the shortcomings of the device for preventing chopsticks from jamming in the storage box outlined in the introduction, we first change the length and shape of the storage box. We then select the storage method and quantity, and plan to feed 300 pairs of chopsticks and use a straight-line drop method as the feeding method. In the third step, we set the feeding method. To employ the straight-line drop method for feeding, a platform is required for the materials to land on, then the feeding mechanism of the platform is used to push and feed the chopsticks. In the fourth step, we design the appearance. Through these four steps, the widths of falling object track and storage boxes are determined, and the feeding system is used for the smooth feeding of the base, as shown in Fig. 2.

After establishing the external dimensions of the new feeding system, we design the feeding mechanism. The feeding mechanism includes a drive motor, lead screw, nut seat, slide rail, and end seat. When the drive motor is started, the coupling rotates the lead screw, so that the worktable above the nut seat moves linearly along the slide rail, as shown in Fig. 3.[8–10]

The design of the feeding system must consider both the mechanism and electrical system. The mechanism includes system stiffness, friction, natural frequency, damping, and motion

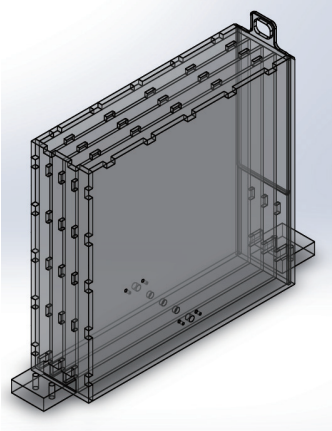

Fig. 2. (Color online) Storage box.

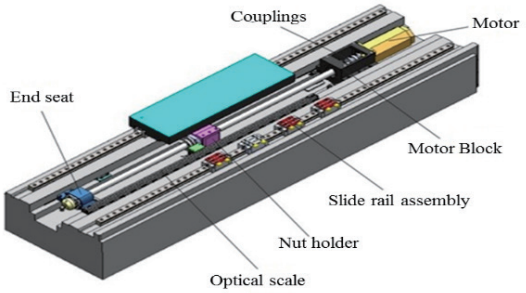

Fig. 3. (Color online) Feeding system.

inertia, whereas the electrical system includes motor torque, acceleration and deceleration capabilities, system stability, position correction, heat dissipation, and control systems. When designing the feeding system, we must first understand the required functions. The operating conditions are set and the appropriate linear slides and lead screws are selected in accordance with the operating conditions. After setting the lead screw and matching the required functions, select the bearing and the arrangement method. Here, there will be different arrangements according to the required accuracy, load weight, and rotation speed of the machine. According to these arrangements, select the appropriate coupling to ensure that the torque will not cause damage to the coupling, and then use the appropriate motor according to the limited torque of the coupling. If the limited torque of the coupling cannot achieve the expected function, the coupling is reselected, thus completing the design of the feeding system. The parts used in our design of the feeding mechanism include a 10 rpm low-speed motor, coupling, lead screw, circular guide rod, linear bearing, and push plate. The shape and support base are designed using a sheet metal drawing. The assembly drawing of the feeding mechanism and support bases is shown in Fig. 4.

Finally, the feeding system is combined with the platform onto which the chopsticks fall, then the feeding mechanism of the platform pushes and feeds the chopsticks. This design is equipped with two storage boxes, which breaks through the previous limitation that a feeder can only transport one type of material, as shown in Fig. 5.

3. Integral Design and Experiment

A photograph of the feeding system of the new automatic rod packing machine is shown in Fig. 6. When the chopsticks fall from the storage box onto the platform, the push plate drives them to the entrance of the falling object track. To achieve feeding, IR sensors are installed in the storage box, the falling object track, and the walking track of the push plate in the feeding system to ensure the accuracy of feeding. The IR sensor of the storage box is set at the bottom of the box. Its main function is to transmit the missing information to the computer when there are only a small number of chopsticks remaining in the system, allowing the user to replenish them

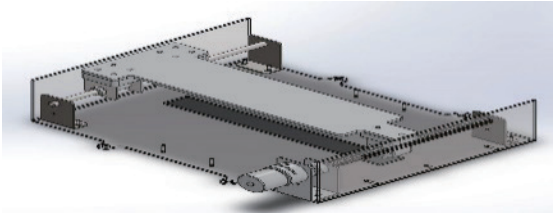

Fig. 4. (Color online) Assembly drawing of feeding mechanism.

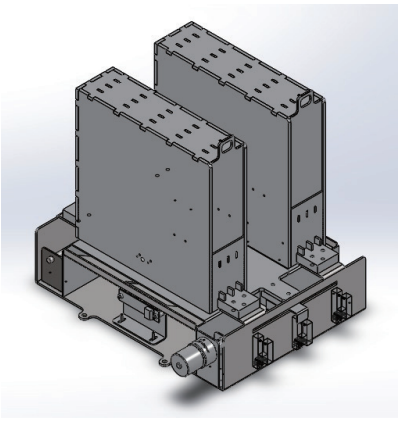

Fig. 5. (Color online) Feeding system and platform onto which falling chopsticks land.

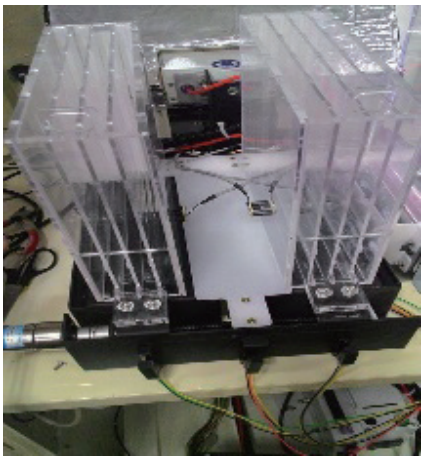

Fig. 6. (Color online) Feeding system of the new automatic rod packing machine.

in time, and the IR sensor of the falling object track is installed in the middle of the track to count the number of dropped chopsticks, allowing the user to know how many chopsticks have passed through the system. Finally, the main function of the IR sensor for the walking track of the push plate is to limit the position of the push plate to prevent it from damage.[11–12] The improved new feeding system is made of sheet metal and then assembled and tested with motors, lead screws, and linear bearings to complete the design of this study. According to the actual results, the four-bar linkage mechanism and the material jam prevention device are easily affected by the defects of the material, and a new feeding system is developed to replace the conventional four-bar linkage feeding system, adding two storage material box designs and improving the feeding efficiency.

4. Conclusions

In this study, the feeding system of a machine for automatically packing rod-shaped objects such as chopsticks was designed with the aim of eliminating the defects of the four-bar linkage and the device that prevents chopsticks from jamming, which are easily affected by stress. The newly designed feeding system was used to replace the conventional feeding system. In the design, the motor, lead screw, and linear bearing are used to replace the four-bar linkage mechanism of the conventional automatic machine to solve all possible states of the chopsticks such as the jamming, shortage, and replenishment of chopsticks. At the same time, the newly designed feeding system can reduce the noise generated by the mechanism when transporting materials, and it can also reduce the damage of the internal mechanism due to stress, thereby reducing the frequency of parts replacement. The improved new feeding system is made of sheet metal and then assembled and tested with motors, lead screws, and linear bearings to complete the design of this study. More importantly, this design is equipped with two storage boxes, which breaks through the previous limitation that a feeder can only transport one type of material. Although a low-speed motor is used in the new design, its speed can be increased in the future to improve the feeding efficiency.

References

1 G. F He and S. R. Gu: Commonwealth Mag. **601** (2016) 1. https://www.cw.com.tw/magazine/magazine.action?id=1389
2 M. Arda: Mach. Technol. Mater. **5** (2020) 186. https://mtmcongress.com/winter/sbornik/2-2020.pdf
3 Ruian Huaze Machinery Co., Ltd.: https:// http://www.rahzjx.com/ (accessed June 2021).
4 Y. M. Abueejela and A. Algitta: Int. J. Innov. Sci., Eng. Technol. **2** (2015) 282. https://www.researchgate.net/publication/277670326
5 T. Gupta and S. Kamboj: Int. J. Mech. Eng. Technol. **9** (2018) 1277. http://iaeme.com/Home/journal/IJMET
6 F. Fathahillah, M. Siswanto, M. Fauziyah, R. Parlindungan, R. I. Putri, and Y. G. Roh: The 1st Annu. Technol., Applied Sci. Eng. Conf. (IOP Conf. Series: Materials Science and Engineering 732, 2020) 1–8.
7 V. M. Bansode, A. A. Giram, O. K. Kamble, and V. A. Gite: J. Sci. Technol. **6** (2021) 586. https://doi.org/10.46243/jst.2021.v6.i04.pp586-596
8 J. Z. Liao: Ind. Technol. Res. Institute **8** (2011) 60. http://hdl.handle.net/11455/98415
9 B. H. Amstead, P. F. Ostwald, and M. L. Begeman: Manufacturing Processes (Wiley, New York, 1987) 8th ed.
10 J. L. Chen: CNC Machine Tool (Quanhua, Taiwan, 2004).
11 J. M. Xu: Ind. Technol. Res. Institute **5** (2015) 70. https://www.itri.org.tw/ListStyle.aspx?DisplayStyle=13_content&SiteID=1&MmmID=1036233405427625204&Trt_idx=5360
12 B. X. Tsai: Mach. Ind. Mag. **321** (2008) 12. https://www.itri.org.tw/ListStyle.aspx?DisplayStyle=18_content&SiteID=1&MmmID=1036452025756363357&MGID=621037654367222174