Motion Simulation Analysis of the Horizontal Sealing Device for the Bulk Material Packaging Machine Based on SOLIDWORKS Motion

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Abstract. In the past, the horizontal sealing mechanism of the bulk material packaging machine has a cam type and a cylinder type. The cylinder type horizontal sealing mechanism has a great impact when the speed changes, while the cam type horizontal sealing mechanism will cause noise and vibration. In this paper, the three-dimensional model of horizontal sealing device for bulk material packaging machine is carried out by SOLIDWORKS software, and the motion simulation analysis is carried out by using the add-in SOLIDWORKS motion. The results show that the acceleration of the horizontal sealing head for the horizontal sealing device occurs in 1/4 and 3/4 of the entire movement cycle. The horizontal sealing device can adjust the speed to meet the horizontal sealing requirements of different packaging bags. The horizontal sealing device of the bulk material packaging machine designed in this paper provides a reference for improving the packaging efficiency of products.

1. Introduction
With the improvement of our people's material living standards and consumption upgrades under the new situation, the development of the commodity economy has become an important means of stimulating economic growth. As packaging is an important part of commodities, especially food commodities, the market has also put forward higher and higher requirements for commodity packaging. Packaging equipment is a major industrial equipment that realizes commodity packaging. It is an important part of the food industry and the machinery industry. With the trend of equipment manufacturing industry upgrading, the development of high-performance packaging equipment is quite urgent [1].

Liu Luo [2] proposed a reciprocating horizontal sealer. The knife holder and horizontal seal frame of this horizontal sealer could realize reciprocating motion. The reciprocating motion was driven by a servo motor. Multiple sets of this mechanism could be used to improve packaging efficiency. Wang Aizong [3] et al. designed a packaging machine. The horizontal sealer of the packaging machine was a fully automatic reciprocating type, which mainly used a D-type internal cam mechanism. This horizontal sealer could solve the poor sealing performance of thick film packaging and the problem of poor packaging effect. Zhao Huiwen [4] et al. conducted dynamics, kinematics analysis and mechanism reliability analysis on the horizontal sealer structure of the D-type track packaging machine, and completed the theoretical research on the principle of the D-type track horizontal sealer using a servo
control system. Jiang Nailiang [5] et al. used the cam linkage mechanism to design the structure and kinematics simulation of the horizontal sealing device for the small-dose and high-speed packaging machine, and wrote part of the control program for the horizontal sealing system.

In the past, the horizontal sealing mechanism of bulk material packaging machine has cam type and cylinder type. The cylinder type horizontal sealing mechanism has a great impact when the speed changes, while the cam type horizontal sealing mechanism will cause noise and vibration [6]. This paper uses SOLIDWORKS software to model the horizontal sealing device of the bulk material packaging machine, and uses the add-in SOLIDWORKS Motion to perform motion simulation analysis [7-11], so as to provide a reference for improving the packaging efficiency of products.

2. Technological process of the bulk material packaging machine

According to the movement mode, the horizontal sealing mechanism of the packaging machine has two types: continuous and intermittent [12-13]. The continuous horizontal sealing mechanism does a fixed-axis rotary motion, and the linear velocity of the horizontal sealing mechanism is required to be synchronized with the linear velocity of the film drawn by the longitudinal sealing mechanism. When the progress of horizontal sealing is greater than the progress of film feeding, film damage will occur. However, when the rate of horizontal sealing is less than the speed of film feeding, it will affect the quality of the sealing [14]. In actual production, the packaging machine needs to complete multiple baggy packaging, and the length of the bag is changed by changing the velocity of the longitudinal sealing mechanism [15]. The technological process of the bulk material packaging machine is shown in Figure 1.

![Figure 1 Technological process of the bulk material packaging machine](image1)

![Figure 2 The horizontal sealing device of bulk material packaging machine](image2)

1.Auxiliary guide, 2. Roller, 3. Horizontal sealing head, 4. Main guide rail, 5. Driving shaft, 6. Bottom plate, 7. Motor
3. Structural design of horizontal sealing device

In this paper, the horizontal sealing device of the bulk material packaging machine is symmetrical with the side of the main guide rail 4, which is driven by the motor 6 on one side, and the driving shaft 5 is driven by the transmission device. The displacement in the direction of guide rail 4 of horizontal head 3 is affected by eccentricity. Under the restraint of guide rail 4, when the driving shaft roller 5 moves on the auxiliary guide 1, it has two actions of sliding and rolling. It drives the horizontal head 3 to move back and forth along the horizontal direction of guide rail 4. With the heating block and horizontal sealing cutter on the longitudinal head, the packaging bag can be sealed longitudinally [6]. The structure of horizontal sealing device for bulk material packaging machine is shown in Figure 2.

4. Simulation methods and steps

4.1. Simulation method

In this paper, SOLIDWORKS software is used to draw the part drawing and assembly drawing of the horizontal sealing device for bulk material packaging machine, and the built-in add-in SOLIDWORKS Motion is used to simulate the movement of the horizontal sealing device, and the displacement, velocity, acceleration and other curves of the horizontal sealing device during the movement are drawn for further analysis and research [16-17]. The motion simulation process is shown in Figure 3.

4.2. Simulation steps

(1) Open the SOLIDWORKS software and import the three-dimensional model shown in Figure 4.

(2) Click Tools, Add-Ins, and then check SOLIDWORKS Motion.

(3) Click ‘Type of Study’, ‘Motion Analysis’. If there is, the add-in has been enabled. If it is not executed as expected, then open the add-in again.

(4) Set a rotary motor for driving shaft 5, adjust the direction, and set the revolutions per minute, as shown in Figure 5.
(5) Define the images within a time range before analyzing the horizontal sealing device, and click ‘Calculate’ to run the motion study.

(6) Click ‘Results and Plots’, and then the ‘Results’ option box will pop up. In the ‘Results’, select ‘Displacement/Velocity/Acceleration’, click ‘Linear Displacement, Linear Velocity, Linear acceleration’ respectively, and click ‘Magnitude’, ‘Create a new plot’ to get the analysis result given in graphical form.

5. Analysis of simulation results
The linear displacement, linear velocity and linear acceleration curves of the bulk material packaging machine are shown in Figure 6, Figure 7, and Figure 8, respectively.

![Figure 5 Motor setting](image)

![Figure 6 Linear displacement](image)

![Figure 7 Linear velocity](image)
Figure 8 Linear acceleration

After the assembly of the horizontal sealing mechanism, the distance between the two guide rails is the farthest, in this case, the above setting drive is used for simulation. It can be seen from Figure 6 that the displacement value of the horizontal sealing head gradually increases to about 630mm during the process of horizontal sealing, and then decreases after stopping working, which is in line with the designed process of making the roller rotate and the driving shaft rotate and reset.

It can be seen from Figure 7 that at the initial position, the horizontal sealing head is the farthest from the main guide rail. At this time, the instantaneous velocity of the driving shaft roller is along the direction of the auxiliary guide rail, and the instantaneous velocity of the vertical frame guide rail is 0. When the driving shaft rotates 1/4 circle, that is, the position where the driving shaft, the roller and the auxiliary guide rail coincide, the instantaneous velocity of the roller is along the frame guide rail direction, after 0.75s, the maximum time of the driving shaft roller velocity is 167mm/s. When the driving shaft rotates 1/2 circle and the horizontal sealing head reaches the nearest end, the instantaneous velocity of the roller is along the direction of the auxiliary guide rail. After 0.75s, the instantaneous velocity of the vertical frame guide rail is 0. In this way, the forward movement of the roller ends, but the return movement is just the opposite, and the same effect is obtained.

It can be seen from Figure 6, Figure 7, and Figure 8 that the linear displacement and linear velocity of the horizontal sealing head movement for the horizontal sealing device designed in this paper are sinusoidal, and the acceleration changes sharply at 1/4 and 3/4 of the entire motion cycle.

6. Conclusions

Compared with the traditional reciprocating horizontal sealing device, the horizontal sealing device has the following advantages: ① The actuator has no pneumatic or hydraulic components, so there is no sealing and pollution problems. ② By adjusting the motor speed to control the horizontal sealing cycle, it can theoretically meet the requirements of horizontal sealing packaging with any bag length. ③ The actuators on both sides are driven by the same driving motor, and the middle part is driven by the same transmission device. Therefore, the force on both sides of the packaging bag is the same during horizontal sealing, and the packaging effect is better.

The motion of the horizontal sealing device for bulk material packaging machine was analyzed by using SOLIDWORKS motion, and the motion parameters of the horizontal sealing head were obtained. It could be concluded from the simulation results that the acceleration of the horizontal sealing head changed dramatically in 1/4 and 3/4 of the entire motion cycle.
References

[1] Wan Qiancheng. Design and Research of Horizontal Sealing Device for High-speed Vertical Pillow Bag Packaging Machine[D]. Wuhan: Hubei University of Technology, 2018.

[2] Wang Aizong, Wang Qingyuan. Automatic Reciprocating Horizontal Sealing Packaging Machine[P]. Shandong: CN103010502 A, 2013-04-03.

[3] Zhao Huiwen. Study on the Performance of Pillow Type Packaging Machine Transverse Sealing Device[D]. Taiyuan: North University of China, 2014.

[4] Jiang Naiiliang. Performance Analysis and Key Component Optimization Design of Small Dose (1-5g) High Speed Packaging Machine[D]. Tianjin: Tianjin University of Science & Technology, 2017.

[5] Liu Luo. Full Servo Reciprocating Packaging Machinery[P]. Henan: CN202657321 U, 2013-01-09.

[6] Xing Yafei, Jin Xiaoyi, Ji Chunyun. Design of Reciprocating Transverse Sealing Mechanism for New Powder Packaging Machine[J]. Light Industry Machinery, 2017, 35(6): 68-71+76.

[7] XING L P, TAN J X, MA Y, et al. Analysis research of the swing mechanism of bamboo separator tool[J]. Journal of Forestry Engineering, 2019, 4(6): 121-126.

[8] WANG D, ZHOU B. Simulation and analysis of internal flow field of variable volume multi-chamber forest fire pump[J]. Journal of Forestry Engineering, 2020, 5(1): 114-121.

[9] HAN J C, JIA H M, LI Y, et al. Temperature and humidity environment simulation and optimum scheme of micro plant factory based on computational fluid dynamics[J]. Journal of Forestry Engineering, 2019, 4(6): 136-142.

[10] LI Y P, LI L J, OUYANG Y B, et al. Experimental study on climbing performance of Camellia oleifera tending machine[J]. Journal of Forestry Engineering, 2019, 4(4): 113-119.

[11] XU F, HUANG X, GU Y F, et al. Research on wind resistance of tree with ellipsoid shape crown based on fluid simulation[J]. Journal of Forestry Engineering, 2019, 4(3): 125-131.

[12] Guo Zhiqiang, Zhu Rumin, Li Donglong. Design and Characteristic Analysis of the Seals and Crosscut Mechanism of Bag Packaging Machine[J]. Journal of Mechanical Transmission, 2013, 37 (10): 65-68.

[13] Zhao Yan, Chen Qiuxia, Wen Kai. The Design of the Control System of the Automatic Packaging Machine[J]. Packaging and Food Machinery, 2015, 33 (2) :42-45.

[14] Khmelev V N, Genne D V, Abramenko D S, et al. The packaging machine for batched packing of pasty products[C]// 2016 17th International Conference of Young Specialists on Micro/Nanotechnologies and Electron Devices. Erlagol, Russia: IEEE, 2016: 257-259.

[15] Sun Huaiyuan, Sun Bo, Yang Liying. Analysis of Use and Maintenance on Blister Packaging Machine[J]. Mechanical and Electrical Information, 2016 (11) :51-59.

[16] YU Yang, YU Guo-sheng, DE Xue-hong, YUAN Da-long, CHEN Zhong-jia. Trajectory simulation of the internal cylinder meshing forming device based on ADAMS method[J]. Journal of Beijing Forestry University, 2014, 36(4): 147-151.

[17] Ning Tingzhou, Hou Shulin. Simulation on Forming Mechnism of Roller Briquetting Machine with Plungers[J]. Journal of Agricultural Mechanization Research, 2017, 39(8): 58-61+65.