Automatic Dispensing Machine Parts Lifting Mechanism Design

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Abstract -- Automatic dispensing machine is a kind of robot equipment for high efficiency dispensing, widely used in electronics, automotive, medical equipment and other manufacturing fields, with high efficiency, accuracy and stability, can greatly improve production efficiency and product quality. In this paper, through the mechanical structure analysis of the automatic dispensing machine, the design of a automatic dispensing machine parts lifting mechanism, to achieve the purpose of conveying of the workpiece. First of all, analyze the working principle of the lifting mechanism of the workpiece, design the overall scheme, and then by comparing different transmission schemes, choose the right transmission scheme of the lifting mechanism of the automatic dispensing machine, and calculate and select the core transmission components. The design calculation includes the calculation of the main parameters of the ball screw and the calculation and selection of the parameters of the motor. The design of this paper can provide a reference for the improvement and optimization of the automatic dispensing machine.

Keywords: automatic dispensing machine; Workpiece lifting structure; Ball screw drive

1. Introduction

A fully automatic dispensing machine is an automated device used for accurate, high-speed, and efficient dispensing operations in industries such as electronics, automotive, and medical devices. Its background can be traced back to the development process of manufacturing industry automation.

With the development of the manufacturing industry and the demand for industrial production, automated production equipment is increasingly applied in production to improve production efficiency and quality. The traditional manual dispensing operation is not only slow and inefficient, but also prone to errors, affecting the quality and stability of the product. Therefore, the research and development and application of automatic dispensing equipment has become a hot field.

Domestic small and medium-sized enterprises in order to improve market competitiveness, improve production efficiency and production quality, need to buy high-precision and high-automation dispensing equipment, automatic dispensing machine related technology is also constantly innovating. Based on this situation, this paper mainly aims at the mechanical structure of the automatic dispensing machine, and designs a workpiece lifting mechanism for

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the automatic dispensing machine to improve the working efficiency of the automatic dispensing machine [1].

2. Research purpose

The research purpose of automatic dispensing machine is to improve production efficiency and product quality, reduce the impact of manual operation on product quality, and reduce production costs. To achieve high precision dispensing, reduce the error in the production process, improve the quality and reliability of products. Automatic dispensing machine parts lifting mechanism is an important part of the automatic production line, through the design of automatic dispensing machine parts lifting mechanism, can improve the automation level of the entire production process, reduce production costs, improve production efficiency and product quality.

On the basis of the three-axis automatic dispensing machine, the workpiece platform on the base is analyzed, and a workpiece lifting mechanism is designed to meet the displacement of the platform in the direction of Z axis, so that the workpiece lifting platform can reach the designated working position, and meet the work flow of the automatic dispensing machine.

3. Analysis of mechanical mechanism

The mechanical structure of the automatic dispensing machine is responsible for completing the movement under the control of the control system, and realizing the transportation function of the workpiece processed by the automatic dispensing machine. The mechanical structure of the automatic dispensing machine mainly includes the working platform and the workpiece lifting mechanism, as shown in Figure 1. The working platform mainly includes the main workbench, the workpiece out, taking, moving parts mechanism and electrical operation box.

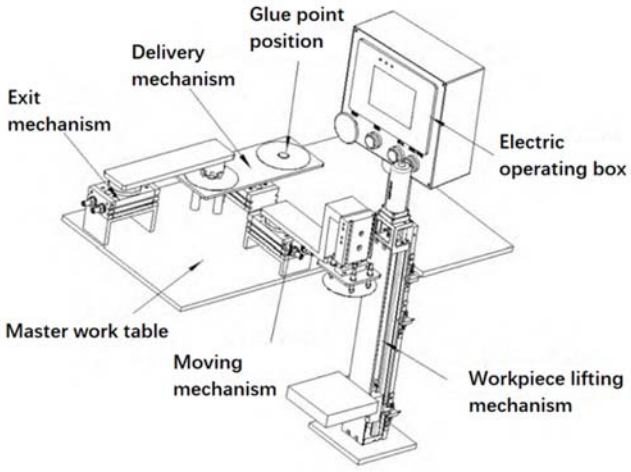
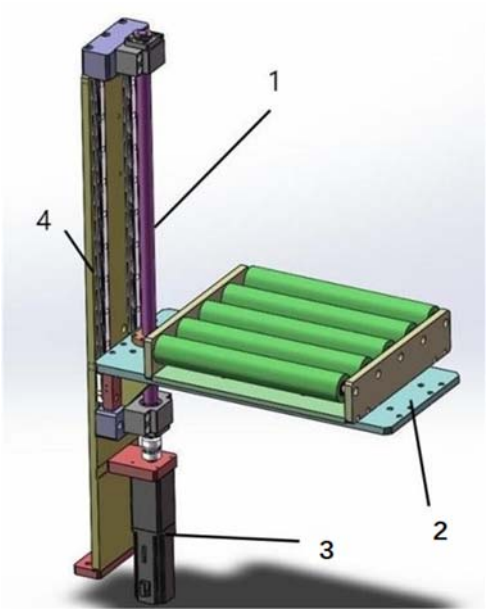


Figure 1. Main working mechanism

The workpiece lifting mechanism of the automatic dispensing machine is usually composed of a bracket, a motor, a transmission mechanism, and a lifting platform. The motor is the power source of the lifting mechanism, which provides the driving force to lift the lifting mechanism up or down. The transmission mechanism is responsible for converting the transmission energy provided by the motor into linear motion, thereby generating power and driving the lifting platform to achieve the workpiece rising or falling. The lifting platform plays the role of lifting the workpiece and can move up and down the platform. See Figure 2.



1- Mechanical structure of lifting mechanism; 2- lifting platform; 3- Motor; 4- connecting plate

Figure 2. Mechanical structure of lifting mechanism

At the beginning of operation, the motor provides transmission energy to the transmission mechanism, which converts the transmission energy into linear motion, thus generating power to drive the lifting platform to achieve the workpiece rise. During the lifting process, the motor drives the transmission mechanism to drive the working platform to rise along the guide rail until the preset height is reached. Entering the working stage, after the lifting platform reaches the preset height, the workpiece is brought to the next working position by the suction device. In the process of falling, the motor drives the transmission mechanism to drive the working platform down along the guide rail until the working platform returns to the starting position. After the lifting platform returns to the starting position, the lifting mechanism stops running.

3.1 Overall scheme selection

- Ball screw can convert rotary motion into linear motion, with high stiffness, high precision, high efficiency, reversible motion and so on. Because its mechanical structure is embedded in the ball between the nut screw, the friction is very small, which increases its accuracy and life compared with other transmission methods [2], and will weaken in vibration, generally with servo or stepper motor can be directly positioned, so choose ball screw drive.

- The screw has the highest static stability and dynamic stability, suitable for highspeed rotation, complex structure, can adjust the preload on both ends of the bearing to improve the stiffness, suitable for a long lead screw, so choose the fixed support at both ends.

- The design of the automatic dispensing machine lifting mechanism for linear motion, the maximum speed of mobile operation is 600mm/s, less than the dynamic pressure guide rail for the minimum speed of 90m/min, and because the lifting mechanism of the workpiece is a small mechanism, simple structure, so choose the linear sliding guide, which is characterized by: stable guidance, easy manufacturing, simple structure. The combination form of guide rail and slide block selects two guide rails commonly used in ball screw set, and the combination of two sliders on each guide rail.

3.2 Overall scheme of workpiece lifting mechanism

Through the selection of the transmission scheme of the workpiece lifting mechanism, the design of the ball screw support scheme and the scheme selection of the ball screw guide rail to determine the overall scheme of the workpiece lifting mechanism, as shown in Figure 3,1 is the motor, providing power for the entire mechanism. Through the 2coupling connecting the motor shaft and the driven shaft of the 3transmission device, it provides power for the 3ball screw, and can be used as a safety device to prevent the transmission mechanism from bearing excessive load. The ball screw drives the 4 platform up and down lifting movement, and the 6guide rail plays a supporting and guiding role, placing the lifting platform offset. 7 The connecting plate is responsible for connecting the components and playing a fixed role.

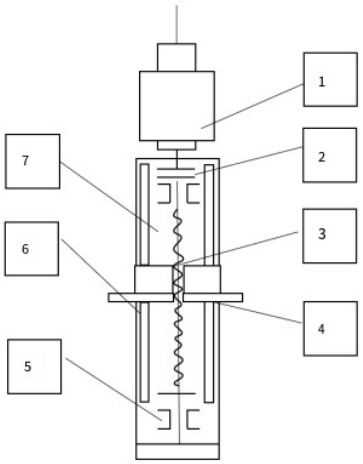


Figure 3. Schematic diagram of the structure of lifting mechanism

4. Zero component parameter calculation of lifting mechanism

The parameter calculation of ball screw can be summarized as follows: First, determine the main parameter accuracy, lead, equivalent load, thread bottom distance and so on according to the set parameter requirements of ball screw; According to the conditions of use pre-selected

specifications such as ball screw diameter, pitch, length, etc.; By calculating the allowable axial load and maximum speed of the ball screw to confirm the basic safety; Finally, adjust and confirm according to the above discussion[3]. According to the requirements of the set parameters, the repeated positioning accuracy of the automatic dispensing machine needs to reach 0.02mm, and the positioning accuracy is 2 times the repeated positioning accuracy. Lifting mechanism travel range 200mm. The overall load bearing W of the lead screw does not exceed 10 kg, and the maximum set operating speed is 600 mm/s.

4.1 Ball screw parameter design

Under normal circumstances, $e_p$it is first necessary to confirm that the target travel tolerance within the effective travel of the ball screw is within the required positioning accuracy range, and then confirm the accuracy level of the ball screw to be used [4]. The target travel tolerance within the effective stroke is approximately the positioning accuracy of the fully automatic dispensing machine, V_{up} is considered that its value is 2 times the value of the repeated positioning accuracy of the fully automatic dispensing machine. By looking up the table for specific positioning with (C series) on behalf of the amount of movement error and change allowable value, for the maximum width corresponding to the effective length of the thread part. The effective stroke is = 200mm, and the positioning accuracy of 0.04mm is greater than 0.023mm, and the positioning accuracy of 0.04mm is greater than 0.023mm, L_s then the accuracy of the ball screw should be determined as C5 level.

4.1.1 Lead calculation

Lead is also called pitch, that is, the distance of linear movement of the nut per rotation of the screw. The calculation formula of the lead is as follows (1): At present, the maximum speed N of the servo motor driving motor popular in the automatic dispensing industry is 3000 r/min[5], then the parameter isN_{max}. V_{max} is the maximum operating speed. According to the maximum speed and maximum running speed of the motor, it can be calculated by the formula (1)

$$P_h \geq \frac{V_{max} \times 60}{N_{max}} = \frac{600 \times 60}{3000} = 13mm \qquad (1)$$

The calculation results show that the lead needs to be more than 13, so it can be provisionally set 16mm.

4.1.2 Ball screw thread base diameter

The general estimate δ_m is that the small value of the estimate is taken as the value. According to the parameter requirements, the positioning accuracy is 0.04mm, the repeated positioning accuracy is 0.02mm, positioning accuracy =8 millimeters according to the minimum principle, take δ_m =5 millimeters.

Estimating the ball screw thread base diameter is Formula (1) The calculation formula of the ball screw thread base diameter is

$$d_{2m} \geq 0.039 \sqrt{\frac{F_0 L}{\delta_m}} \qquad (2)$$

4.1.3 Equivalent load calculation F_m

According to the actual operation situation, the speed and time summary of the operation mode of the automatic dispensing machine is drawn up. The general acceleration and deceleration of each shaft of the automatic dispensing machine is 0.1s to 0.2s, and the average t= 0.15s.

Calculate the average axial load by the formula (2):

$$F_m = \sqrt[3]{\frac{F_1^3 n_1 t_1 + F_2^3 n_2 t_2 + \cdots + F_n^3 n_n t_n}{n_1 t_1 + n_2 t_2 + \cdots + n_n t_n}} \quad (3) = 32.8N$$

Calculate the average axial speed according to the following formula (3):

$$N_m = \frac{N_1 t_1 + N_2 t_2 + N_3 t_3}{t_1 + t_2 + t_3} = 2118r/min \quad (4)$$

4.1.4 Calculation of rated dynamic loadC_{am}

From the lead screw precision bit 5, the precision coefficient =0.9, the reliability coefficient =1, From the lead screw precision bit 5, the precision coefficient =0.9, the reliability coefficient =1, $f_a f_c f_w$and the load property coefficient =1.1.

The rated dynamic load is calculated by the C_{am} following formula (4)

$$C_{am} = f_w F_m (L_S/P_h)/f_a f_c \quad (5)$$

The calculated result is $501N$

4.2 Ball screw connection motor parameter design

By checking the product parameters, the maximum instantaneous torque value of the 100 W is 3.8, the 200 W is 1.91, both greater than the maximum torque 0.48, indicating that when the speed of 600 mm/s is in line with the requirements, the motor speed must also meet the needs of the lifting mechanism when the lifting mechanism runs smoothly. Confirm the effective torque according to the calculation of the effective torque is.$25N \cdot mm$

By referring to the MSME series motor parameter information manual, the product parameters can be found that the rated torque value of 100 W is 1.3[6] and that of 200 W is 0.64, both of which are greater than the effective torque 0.25 when the speed is 600 mm/s. The calculated torque has a large margin, and the inertia ratio also meets the requirements. To sum up, the rated power is $100W$, the rated torque value is 1.3, the full load speed is $3000r/min$, and the final selection model is MSME12 motor.

4.3 Coupler

The function of the coupling is to firmly connect the drive shaft motor shaft and the driven shaft screw in the $T_c$workpiece lifting mechanism to rotate together and transfer the movement and torque of the mechanical parts. And as a safety device to prevent connecting parts from bearing too much load, play the role of overload protection. The coupling type of ball screw is generally diaphragm type coupling, which is characterized by simple structure, convenient installation and disassembly, maintenance, T_n cushioning and damping effect, high safety

factor, good wear resistance, low processing accuracy requirements, and wide range of application. Meet the requirements of this design. When choosing a coupling, it is generally based on the principle that the calculated torque required for transmission of the coupling is less than the allowable stress of the selected coupling or the nominal torque of the standard coupling. Due to the different nature of the transmission shaft load change and the different structural characteristics and performance of the coupling itself, the actual torque transmitted by the coupling is not equal to the torque T required by the transmission shaft system in theory [7], according to the calculated torque, select a brand diaphragm type coupling, model $DY10-30-16-8\ coupling.T_c$

5. Conclusions

This design is mainly based on the Baumgartner DJ[8], set the design should meet the parameters, based on this lifting mechanism design. First of all, the lifting mechanism of the common transmission scheme is analyzed, according to the characteristics of different transmission schemes, the ball screw suitable for this design is selected as the lifting mechanism of the transmission scheme, which is characterized by high transmission efficiency, small friction loss, long life, high precision, very suitable for the automatic dispensing machine parts of the lifting mechanism transmission scheme. Then according to the effective stroke of the ball screw select "one end fixed, one end free" supporting mode, suitable for small stroke and vertical installation of the ball screw. At the same time, select the suitable guide rail for ball screw to achieve support and guidance, and set a reasonable lifting platform size according to the dispensing range[9]. Then according to the set parameters, the main parameters of the ball screw are calculated and selected; By calculating the moment of inertia, speed and torque of the motor, select the motor lower than the required power; Calculate the torque to be transferred to select the appropriate diaphragm coupling. And the drawing of assembly drawings and parts drawings.

However, after this design, it is also necessary to make improvements in some aspects:

For this design, the choice of the scheme is only related to the structure, and does not involve the control design. I hope to learn and understand the self-locking control of the ball screw in the future[10].

The design of the transmission mechanism chooses the ball screw, but mainly through the calculation of the core parameters of the ball screw selection, for the design of the ball cycle, the raceway method is not deeply understood. I hope to have the opportunity to learn in detail in the future.

In the design of the lifting mechanism, the scheme is more suitable for the lifting of the workpiece with short stroke and small load, but in the future, the design is suitable for the lifting mechanism with long stroke, large load and high speed.

References

[1]. Zhao Mengyang. Structural Design of Film winding and lifting device for stage [J]. New Industrialization,2022,12(11)

[2]. Guoquan Qing. Application of Dispensing Robot [M]. Southwest Jiaotong University Press, 2006,23 (1) : 35-37.
[3]. Yang Lin, Wang Di, Jin Fukai. Synchronous Motion Design of Hydraulic Lifting Mechanism of RGV Trolley [J]. Automotive Technologist,.2022.11.008.
[4]. Gao Jianshu, Ma Linkai, Meng Xiangsen et al. Airport transfer baggage car lifting mechanism design and analysis [J]. Journal of mechanical design and manufacturing, 2022 (10) : 19-22 + 27. DOI: 10.19356 / j.carol carroll nki. 1001-3997.2022.10.046.
[5]. Zou Lilian, Sun Yitian, Meng Fanqiang. Development and Design of an Automatic Lifting and Unloading Mechanism for Production Line [J]. Mechanical Engineer,2010(02):132-133.
[6]. Sun Lei, Gao Shunen, Su Xuewei. Discussion on Two Kinds of Lifting Mechanism [J]. Equipment Manufacturing Technology,2015(10):199-200+204.
[7]. Shahriar Bazyari. A Study on the Effects of Solar Tracking Systems on the Performance of Photovoltaic PowerPlants[A]. America:ScientificResearch Publishing ,2014,11:718-728.
[8]. Baumgartner DJ ,Werner Ptzi, Freislich H . et al. An automated method for the evaluation of the pointing accuracy of Sun-tracking devices[J].Atmospheric Measurement Techniques, 2017.
[9]. Zhao Hangyu. Development of Automatic On-line Dispensing Machine [D]. Harbin Institute of Technology,2018.
[10]. Rasmiyeh A ,Reza M V ,Korosh J .Stimated Body Fat Percentage using Mechine Learning Techniques[J].journal of ilam university of medical sciences,2017,25(4):171-178.