Research on Precision Control and Optimization of Automatic Feeding Device of Stamping Die

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Abstract: This paper discusses the precision control and optimization method of automatic feeding device of stamping die. By analyzing the accuracy of the existing feeding device, the main influencing factors are identified. To solve these problems, a comprehensive scheme of structural design optimization, control system improvement and precision test method optimization is proposed. The specific research contents include the improvement of the mechanical structure of the feeding device, the application of advanced algorithms in the control system, and the improvement of precision testing equipment and methods. Through experimental verification, the optimized feeding device has been significantly improved in precision and efficiency, effectively reducing the scrap rate in production, improving the overall production efficiency and product quality, and providing important technical support for precision manufacturing in industrial production.

Keywords: Stamping Die, Automatic Feeding Device, Precision Control, Optimization

1. Introduction

Stamping die plays a key role in modern manufacturing industry, which is widely used in automotive, electronics and other industries. The automatic feeding device is an important part of the stamping die, and its precision control directly affects the product quality and production efficiency. However, the existing automatic feeding devices generally have the problem of insufficient accuracy in practical applications, which not only leads to a high rejection rate, but also increases the production cost. The accuracy problem mainly stems from the design defects of the mechanical structure and control system. Through in-depth study of these problems, a series of optimization schemes are proposed to improve the accuracy of automatic feeding devices, so as to improve the overall production efficiency and product quality, and provide more reliable technical support for industrial production.

2. The Status Quo of Automatic Feeding Device of Stamping Die

2.1 Structure and Function of Existing Devices

The automatic feeding device of stamping mold is an indispensable part of modern manufacturing industry, and its structure and function determine its performance in the production process. The existing feeding device mainly includes the following parts, (1) the mechanical transmission part, including motors, gears, belts and other transmission devices, which are used to transmit power to the feeding mechanism; the feeding mechanism is the core part of the whole device, usually composed of a roller, gripper, guide rail, etc. The main function is to refine the material according to the setting. The degree and speed are transported to the working position of the mold; (2) Control system, modern automatic feeding device is generally controlled by numerical control system (CNC) or programmable logic controller (PLC) to accurately control the speed, position and rhythm of feeding through preset programs and sensor feedback; (3) detection and feedback device The device is equipped with various sensors and detection devices, such as position sensors, speed sensors, etc., to monitor various parameters in the feeding process in real time, and feedback the data to the control system for dynamic adjustment; (4) auxiliary devices, including lubrication system, cooling system and safety protection devices, to ensure that the device is in operation. Stability and security.

2. 2 Problems that Exist

Although the existing automatic feeding device is relatively perfect in structure and function, there are still some problems in practical application, which are mainly reflected in the following aspects. First, the feeding accuracy is insufficient. Because the mechanical transmission part and the feeding mechanism are prone to wear during long-term use, the response speed of the control system The degree and algorithm limitations also affect the accuracy, especially in the process of high-frequency feeding, the problem of inaccurate positioning often occurs, resulting in an increase in the size error of the stamping part. Second, the stability of the control system is insufficient. In high-speed and mass production, it is vulnerable to external interference, resulting in failure or misoperation, affecting production efficiency and may cause equipment damage and safety accidents. The sensitivity and accuracy of the detection device also need to be improved. In harsh environments such as high temperature and high humidity, the decline in the performance of the position sensor affects the accuracy of the detection results, which in turn affects the overall feeding accuracy. Third, the structure of the automatic feeding device is complex, and the daily maintenance and maintenance workload is large, which requires professional and technical personnel, which increases the maintenance cost and human resources investment of the enterprise. High-precision automatic feeding devices are expensive, and their operation and maintenance costs are high, which limits their popularity among small and medium-sized enterprises. In view of these problems, it is necessary to optimize the structure in the design and manufacture of the device, improve the response speed and stability of the control system, improve the accuracy and sensitivity of the detection device, and simplify the maintenance process to improve the overall performance and reliability of the automatic feeding device, so as to effectively improve the feeding accuracy and reduce the production. Production cost, improve production efficiency and product quality.

3. The Key Factors of Precision Control of the Feeding Device

3.1 Effect of Mechanical Structure on Accuracy

(1) Mechanical transmission part of the impact

The mechanical transmission part is the core part of the feeding device, and its accuracy directly affects the conveying accuracy of the material. The precision of the motor and gears determines the stability and accuracy of the transmission system. If there is a gap or wear in the gear drive, it will lead to transmission errors and affect the accuracy of the feed. Although the belt drive has low noise and smooth operation, it is prone to slack and wear after long-term use, which will also affect the accuracy. Therefore, the selection of high-precision, high-wear materials, and regular inspection and replacement of transmission parts are important measures to improve the accuracy of feeding.

(2)The impact of rollers and guide rails

The roller and guide rail are very important for the feeding device, and their design and installation accuracy have a direct impact on the straightness and positioning accuracy of the feeding. The roundness and surface finish of the roller will affect the smooth transportation of materials, and the straightness and smoothness of the guide rail determine the friction resistance and movement trajectory in the process of material transportation. If the guide rail is not installed unevenly or the surface is defective, it will cause the material to shake and offset during the conveying process, affecting the accuracy of feeding. Therefore, in the design and manufacturing process, the accuracy of the roller and guide rail should be strictly controlled, and accurately aligned and adjusted during installation.

(3)Influence of structural design

The overall structure design of the feeding device is also an important factor affecting the accuracy. Reasonable structure design can reduce the transmission error and vibration of the device, so as to improve the feeding accuracy. For example, the use of dual guide design can improve the rigidity and stability of the device, reduce the jitter during the material handling process. In addition, by optimizing the structure design and reducing the length and complexity of the transmission chain, the transmission error and the maintenance difficulty of the device can be effectively reduced. Therefore, the optimization of structure design is an important way to improve the accuracy of the feeding device.

3.2 Influence of Control System on Accuracy

(1)Influence of control algorithm

The core of a control system lies in its control algorithm. The advanced control algorithm can process the information fed back by the sensor in real time, and quickly adjust the speed and position of the feed, thereby improving the accuracy. The commonly used control algorithms include PID control, fuzzy control and neural network control. PID control is widely used in industrial control because of its simplicity and stability. However, for complex feeding process, PID control is sometimes difficult to cope with dynamic changes, and it is necessary to combine fuzzy control or neural network control to improve accuracy. For example, fuzzy control can be adjusted according to empirical rules, and neural network control can optimize control parameters through self-learning, thus achieving higher control accuracy.

(2) Impact of feedback system

The feedback system is an important part of the control system, and its accuracy and response speed directly affect the accuracy of feeding. Common feedback devices include position sensors, speed sensors and acceleration sensors. These sensors need high sensitivity and high precision to monitor various parameters in the feeding process in real time and feed the data back to the control system for dynamic adjustment. For example, the position sensor is used to detect the position change of materials, the speed sensor is used to monitor the feeding speed, and the acceleration sensor is used to detect the vibration of the device. Through multi-sensor fusion technology, the reliability and accuracy of the feedback system can be improved, and the accuracy of the feeding device can be further improved.

(3) Hardware Configuration of the control system

The hardware configuration of the control system is also an important factor affecting the accuracy. High-performance controllers and drivers can achieve faster computing speed and higher control accuracy. For example, the use of high-speed processors and high-precision AD/DA converters can improve the response speed and accuracy of the control system. In addition, the anti-interference ability of the control system is also crucial, in the actual production environment, electromagnetic interference, temperature changes and other factors will affect the stability and accuracy of the control system. By adopting anti-interference design and shielding measures, the reliability and stability of the control system can be improved, so as to ensure the feeding accuracy.

(4)Software Optimization

The software part of the control system also has an important impact on the accuracy. The design and optimization of the control program is directly related to the control effect of the system. Excellent software design can improve the computing efficiency and real-time performance of the system and reduce the control delay. By optimizing the control program and reducing unnecessary operation steps and redundant code, the overall performance of the control system can be improved. In addition, the use of advanced software development tools and debugging methods can further improve the accuracy and stability of the control system.

4. Optimal Design of Feeding Device

4.1 Structural Optimization

Structural optimization is an important means to improve the accuracy and performance of the feeding device. Through the design and improvement of the mechanical structure, the transmission error can be effectively reduced and the stability and accuracy of the feeding can be improved. As the core part of the feeding device, the design of the transmission system directly affects the accuracy and efficiency of the feeding. In order to improve the performance of the transmission system, high-precision gears, ball screws and other transmission components can be selected to reduce the transmission gap and error. For example, the use of pre-loaded ball screw can eliminate axial clearance and improve transmission accuracy. In addition, through reasonable structural design, the length of the transmission chain is shortened as much as possible and the accumulation of transmission error is reduced. The use of direct drive motor can save the intermediate transmission link and further reduce the error. At the same time, optimize the transmission ratio design, reasonably design the transmission ratio according to the actual working conditions, ensure the operation of the motor in the best working range, and improve the efficiency and stability of the transmission system. The optimization of the guide rail system can also significantly improve the straightness and positioning accuracy in the feeding process. High-precision linear guides and sliders are selected to reduce the friction and clearance of the guide rails and improve the stability and accuracy of movement. For example, using silent guide rails can reduce noise and improve comfort. Reasonable layout of guide rails to ensure uniform force and reduce the deformation and jitter of guide rails. For example, the use of double guide rail design can improve the rigidity and stability of the guide rail system. Add a dustproof device to the guide rail system to prevent dust and debris from entering the guide rail, reduce the wear and pollution of the guide rail, and prolong its service life. Improving the structural rigidity of the feeding device can effectively reduce vibration and deformation, and improve the stability and accuracy of feeding. Add the support structure in key parts to improve the overall rigidity. For example, adding reinforcements at the connection between the guide rail and the transmission system can reduce vibration and deformation.

4.2 Control System Optimization

The optimization of the control system is another important way to improve the accuracy and efficiency of the feeding device. By improving the control algorithm, improving the accuracy of the feedback system and optimizing the control software, the performance of the system can be significantly improved. The optimization of the control algorithm is the core of improving the performance of the control system. By adopting advanced control algorithms, the accuracy and stability of feeding can be improved. For example, fuzzy control, neural network control and other advanced control algorithms are adopted to replace traditional PID control and improve the adaptive ability and accuracy of the control system. Neural network control can optimize control parameters through self-learning to adapt to complex working conditions; multi-variable control strategy is aimed at multi-input and multi-output system, improving the coordination and stability of the system; real-time optimization control realizes optimal control by real-time monitoring of the system status and dynamically adjusting control parameters, such as adaptive control algorithms can Adjust the control strategy in real time according to the system status to maintain the best performance. The feedback system is an important part of the control system, and its accuracy and response speed directly affect the control effect. The optimized feedback system can improve the accuracy of position detection by selecting high-precision sensors such as photoelectric encoders, and adopt multi-sensor fusion technology to improve the reliability and accuracy of the feedback system, such as combining the data of position sensors and acceleration sensors to more accurately monitor the status of the system; by optimizing sensing The interface between the device and the control system reduces the data transmission delay and improves the response speed of the feedback system. For example, the high-speed communication protocol is adopted to improve the real-time of the feedback data. The optimization of control software can significantly improve the efficiency and stability of the control system. Optimize the control program to simplify the structure, reduce redundant code, and improve execution efficiency, such as reducing calculation time and improving system response speed by optimizing code logic; adopt advanced software development tools and testing methods to ensure the reliability and stability of control software, conduct strict software testing and verification, discovery and repair Recover potential errors and improve system stability; enhance the human-computer interaction interface, optimize the human-computer interaction interface of the control software, and improve the convenience and safety of operation, such as designing an intuitive operation interface and alarm system to help operators quickly find and deal with faults and improve production efficiency.

5. Accuracy Testing and Experimental Verification

5.1 Accuracy Test Method

In order to evaluate the accuracy of the automatic feeding device, the accuracy test of the system must be carried out. The test method mainly includes the following steps. (1) Select high-precision measurement equipment, such as laser interferometer, optical encoder and high-precision displacement sensor, to ensure the accuracy of the measurement results. Laser interferometer is used to measure straightness and positioning accuracy, optical encoder is used to measure angle and speed, and displacement sensor is used to monitor small displacement changes during feeding in real time. (2) Strictly control the test environment to ensure the stability and consistency of the test results. For example, the temperature and humidity of the test room should be kept constant to avoid environmental changes affecting the measurement results. (3) The test surface should be flat and stable to reduce the interference of external vibration to the test. Then, develop detailed test procedures to ensure that the conditions and steps of each test are consistent. The test program includes steps such as warming up the equipment, adjusting the test equipment, recording the initial state, gradually increasing the load for testing, recording measurement data and analyzing data. In each test stage, the accuracy performance of the feeding device at different speeds, loads and working conditions is recorded separately. (4) Use the data acquisition system to record test data in real time and analyze data. Through statistical analysis software, the measurement data is processed, and key indicators such as positioning error, repeated positioning error and straightness error of the device are calculated. By comparing the test data under different working conditions, the impact of optimization measures on feeding accuracy is evaluated.

5.2 Analysis of Experimental Results

Through the analysis of the test data, the following conclusions can be drawn, through the laser interferometer measurement data, analyze the positioning accuracy of the feeding device. The positioning error of the optimized device is obviously reduced and the positioning accuracy is significantly improved under different speeds and loads. For example, under high-speed conditions, the positioning error of the optimized device is reduced from the original 0.05 mm to 0.01 mm, which proves the effectiveness of the optimized design to improve the positioning accuracy. Using the data of optical encoder, the repeated positioning accuracy of the device is analyzed. The test results show that the repeated error of the optimized device is reduced from 0.02 mm to 0.005 mm in the process of repeated positioning, showing higher stability and consistency. The straightness error in the feeding process is analyzed by the data of high precision displacement sensor. After optimization, the straightness error of the device under different loads is significantly reduced, and the feeding path is more stable and accurate. For example, at full load, the straightness error is reduced from 0.03 mm to 0.01 mm, indicating that the optimized device has better straightness control. Combined with the analysis results of positioning accuracy, repeated positioning accuracy and straightness error, the comprehensive performance evaluation is carried out. The optimized feeding device has excellent performance in various test indexes, indicating that the accuracy and performance of the feeding device have been significantly improved through structural optimization and control system optimization. The experimental results verify the effectiveness of the optimized design, and provide reliable data support and technical reference for the subsequent practical application.

6. Conclusion

Based on the research of precision control and optimization of automatic feeding device of stamping die, this paper puts forward a series of effective improvement schemes, and verifies their feasibility and effectiveness through experiments. The optimized feeding device significantly improves the accuracy and production efficiency, and provides reliable technical support for industrial production.

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