

Design of Gearbox in Pentahedral Machining Center

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Abstract. The lathe bed is an important part of the machine tool. It plays the role of supporting the column, the table and other components. The performance of machine bed tool directly affects the machining precision of the machine tool. In the process of dynamic optimization design of HX7910 pentahedral machining center, the finite element model establishment of HX7910 pentahedral machining center bed was established, and its first six order modes were analyzed. According to the results of the analysis, the rib plates were determined as the optimized objects and dynamic sensitivity analysis was carried out for the rib plate structure inside the bed by using the sensitivity optimization method. On the basis of sensitivity analysis, the structural optimization design was carried out to get the structural parameters, which improves the dynamic characteristics of the machining center bed and the performance of the bed.

Introduction

Machine tools are industrial infrastructure. The large-scale CNC machine tools and precision CNC machine tools level also reflects the country's industrial development level. So the development of large-scale processing center and soon formation of industrial scale not only has great significance in the development of equipment manufacturing industry. The rationality and advancement of the design method of large-scale CNC machine tools play a decisive role in the success or failure of product development.

Product development mainly includes program design, component design, parts design, product prototype manufacturing and so on. This paper introduces the overall design process of a full-featured large-scale gantry pentahedral machining center. The overall program design includes: machine parameter development, overall layout of the initial development, three-way coordinate stroke development, the layout and structure of main parts and overall program development.

Vertical Lathe

Because of the accurate transmission ratio, high transmission efficiency, reliable transmission, low failure rate, the main transmission case of vertical lathe, that is, gearbox is still the main structure of vertical lathe for the main transmission speed. Traditional vertical lathe achieves gear meshing off through the multi-stage gear drive and up and down movement of shifting fork, with two gears speed. Through the motor speed adjustment, the required speed of table can be achieved to meet the turning requirements. As in recent years the mechanical processing industry has increasing demand for turning and milling complex machining center, the original vertical lathe gearbox variable speed range is put forward new requirements, from the original two gears to three gears variable speed, that is, high-speed gears, low speed gears and neutral gears. In the implementation of the turning action, two gears are achieved; in the implementation of the milling operation, the gearbox gear and table base of the transmission gear should be off, to achieve the required power of sub-degree and transmission through the axle box.

The main drive system of vertical turn-milling machining center is driven by the DC motor, through the multi-stage gear drive speed reduction, to achieve the required rotation speed of the table. The original variable speed cylinder was made structural transformation, increasing a hydraulic oil chamber, to make the shifting fork off through the piston rod movement inside hydraulic cylinder to achieve three gears variable speed. The specific gear transmission structure is shown in Figure 1, and hydraulic cylinder structure is shown in Figure 2, and the hydraulic schematic diagram is shown in Figure 3.







Lathe Parameters Determination

Product development needs to be determined based on market demand conditions. First of all, the market demand should be fully learned and the processing technology should be communicated with the customer group to understand the customers' required product specifications, process

parameters, processing accuracy and other requirements. The machine parameters should be determined by comparing the specifications of foreign similar products in the domestic sales, combining with the enterprise's product planning, process level and other factors. In the establishment of machine positioning at high speed, high precision and high automation, the main parameters of the machine is shown in Table 1.

Maximum diameter of the tool	250		
mm			
Maximum length of the tool mm	400		
Processing feed/rapid feed	0.5 - 15 000		
Maximum speed of mainshaft rpm	10 - 3 500		
Mainshaft power kW	37/51		
Torque of mainshaft Nm	1200 - 1500		
Dimension of bed mm	4 000f2 000		
Workpiece dimension mm	4 000f2 000f1		
	000		
Bed load-bearing	20 T		

Table 1	Main p	parameters	of the	lathe

Initial Development of Entire Distribution

According to the initially determined parameters and the reflected processing range, performance of the lathe, thee initial overall layout is determined. The correctness of overall layout of the lathe is directly related to the correctness of the product development direction and the development cycle. Taking the model as an example, the size of the workpiece is large but it is divided from the total loading mass, so it does not belong to the heavy machine tool series. High speed and high precision is still the main design goal. Therefore, the overall layout adopts the fixed gantry frame. Compared with the type of gantry frame, although the size of the workpiece has certain restrictions, the X direction of fixed gantry adopts bed movement. The distance from the drive center and the gravity center of the moving parts is shorter than the mobile gantry; when the workpiece is put on the bed, the stability of fast moving is better than the movement mode by using gantry frame, and easier to ensure accuracy. In order to improve the degree of automation and improve the efficiency of lathe, in addition to equipping with automatic tool change system, automatic replacement of the head system, workbench exchange system are also added.

Layout and Structure of the Main Parts

The rationality of the main parts layout and the feasibility of the structure not only relate to the overall size of the lathe, but also directly affect the machine processing performance and processing range. In order to ensure the accuracy, rigidity, reliability and other indicators of the lathe, in the layout and structure of the main parts, the development process should be considered with more relevant details. Take this model as an example:

The basic components structure in X direction use segmented casting bed. Several sections form a complete bed. The advantage of this structure is a high degree of modularity. Different length of bed can be composed according to the travel need. And the bed is laid on the axis of the entire machine. The slide support is supported by four linear guide rails. The guide rails are connected to the bed, and the inner guide rails are positioned by the special wedge-shaped block. Compared with the conventional guide rails used in the past, the distance from driving force and cutting force to the point of action on the reference rail is shortened and the torque is reduced, so that the deformation of reference rail affected by the torque is reduced, to improve the slider movement smoothness and accuracy in X direction.

The drive mode in X direction is to drive small diameter toothed pulley F toothed belt F large diameter pulley to rotate by servo motor, in which the large diameter pulley is connected with nut,

driving the nut rotation (screw fixed) to promote the slide perform horizontal movement on the bed. The reason for this structure is that the X-direction travel is too long and the deflection of the lead screw affected by the gravity is too large. When the side is moved at 15 m/min, the rotation speed of the lead screw is calculated beyond the limit speed of the screw.

In order to ensure the rapid feed rate and reduce the impact of deflection on the transmission accuracy, the transmission structure of nut rotation is used. The work table is connected with the slider through eight clamping oil cylinders. The top of the slider is arranged with two rows of multi-row cylinder floaters. The main function of the floaters is to ensure the work table is disengaged when it is exchanged. The fixed gantry is made up of two uprights and one beam. These two uprights stand on both sides of the bed.

Y direction drive mode is to drive the transmission mechanism composed of the reducer, lead screw driven by the servo motor. The nut fixed on the saddle push it move in horizontal direction on the fixed gantry column. To improve the support rigidity of moving parts, the guide rail uses sliding rail and is equipped with rolling unloading device to reduce the specific pressure of sliding guide, reduce the rail wear and tear and ensure the ability of coordinate axis to quickly feed. The ram moves vertically in the saddle. The guide rail is the sliding guide. The clamping device is installed on two sides of guide rails of the ram. High-power cutting can be carried out after clamping the ram. Z-direction drive mode is the same as Y-direction drive. To offset the ram weight and reduce Y-direction driving force, two cylinders are mounted on both sides of a square ram with a size of 450 mmf480 mm to apply a force opposite to the direction of gravity to the ram to balance the weight of the ram.

General plan Making

Through the above steps, and the overall appearance and size of the lathe is ultimately determined. Then the program drawing is completed further to determine the location of the main parts of the entire model, as shown in Figure 4.



Fig.4 Airframe design

1 bed and X-direction drive 2 slide and table 3 gantry column and Y-direction drive 4 saddle, ram and Z-direction drive 5 tool changer 6 table exchange station 7 accessory head storeroom

Conclusion

Under the premise of ensuring the normal function of lathe and human engineering requirements machine layout should strive to compact. In order to faster, more refined and better complete product design, other product design experience should be learned. Through the introduction of the overall design of this model, the process in the overall design stage of the gantry pentahedra machining center and some details that should be taken into account in the process of parameter and structure development can be learned. This design method has successfully completed the product



development project of full-featured large-scale gantry pentahedra processing center. And this gearbox can achieve variable speed requirements, with high transmission accuracy, simple debugging and reliable structure, and have accepted by the users. It has now become the standard configuration in our factory and has good prospects for development.

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