Application of Bearing in Sliding Gear Variable Speed Mechanism of NC Machine Tool

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Abstract

Aiming at the problems of quick wear and tear, high calorific value, low transmission accuracy and high noise of the gear sliding transmission mechanism in the spindle box of machine tool, this paper adopts the method of assembling the shifting fork, splint, bearing and spline sleeve together. Applying the characteristics of relative rotation of the inner and outer rings of the bearing, a method of sliding transmission of gears in the spindle box of NC machine tool is put forward, which solves the problem of sliding transmission of gears in the spindle When the spindle box is changing speed, some problems such as unstable meshing of gears and high noise occur, which greatly improves the transmission accuracy of NC machine tools.

Keywords

Sliding gear;NC Machine Tool;Transmission accuracy.

1. Introduction

The main drive system of NC machine tools generally has three forms: synchronous belt drive, direct spindle drive and gear transmission. In large and medium-sized machine tools, the main motion speed regulation range is large, and the speed regulation motor alone can not meet the large speed regulation range, and the power and torque characteristics of the speed regulation motor are difficult to directly match the power and torque requirements of the machine tool [1]. In order to meet the requirements of large constant power range and low speed and large torque in machine tool processing, the main transmission system of CNC machine tool is often connected with mechanical stepless speed change mechanism in series after CVT motor. As a mechanical stepped transmission mechanism, sliding gear transmission is often used in the main drive of NC machine tools. The common sliding gear transmission mechanism is to change the speed by shifting the sliding gear on the spline shaft with a fork. There are many problems affecting the transmission accuracy of machine tools in this way, such as: (1) the contact wear of gears and forks, reducing transmission accuracy and increasing gear calorific value; (2) some manufacturers reserve a gap between forks and gear ring grooves to prevent contact wear between forks and gears, but it will result in poor accuracy of gear sliding displacement, unstable meshing and high noise. (3) When the hydraulic system of machine tool leaks or stops suddenly, the sliding gear will slip uncontrollably under the influence of gravity or other factors, resulting in gear teeth and other accidents. Aiming at the problems of traditional gear sliding mechanism, a new gear sliding mode is proposed in this paper, which meets the characteristics of large speed range, large cutting torque, high transmission accuracy, stable speed change and low noise of the main drive system of NC machine tools.

2. Sliding Gear transmission mechanism

Among the common gear sliding transmission mechanisms, there are roughly the following kinds of gear sliding modes: as shown in Figure 1, the gear shifting mechanism in the spindle box of C616 lathe is expanded. In this way, the sliding gear is assembled on the spline sleeve, and the spline sleeve is moved by the dialing fork to realize the sliding of the gear on the shaft. This way avoids the direct contact between the dialing fork and the gear, but the dialing fork will still wear and tear with the connecting sleeve. In the figure, the connecting sleeve is assembled with the sliding gear 2 and spline sleeve, and the transmission handle outside the manual operating box makes the fork move left or right to realize the sliding engagement of the sliding gear and complete the transmission. When the spline shaft rotates, the fork contacts and rubs with the connecting sleeve all the time, which not only reduces the gear transmission accuracy, but also accelerates the wear of gears, fork and other transmission parts. Another common way is to assemble the sliding gear on the spline shaft, and to shift the side of the sliding gear directly through the fork to achieve speed change. When the spline shaft rotates, the fork contacts the sliding gear directly, which seriously affects the transmission accuracy and the service life of the gear. In view of the above problems existing in common sliding gear transmission mechanism, this paper ingeniously utilizes the characteristics of relatively flexible movement of bearing inner and outer rings, applies deep groove ball bearing to gear sliding transmission mechanism, designs a bearing-based gear sliding transmission mechanism, which can effectively avoid the problems existing in traditional transmission mechanism and greatly improve the transmission accuracy and performance of machine tools, automobiles and other equipment.

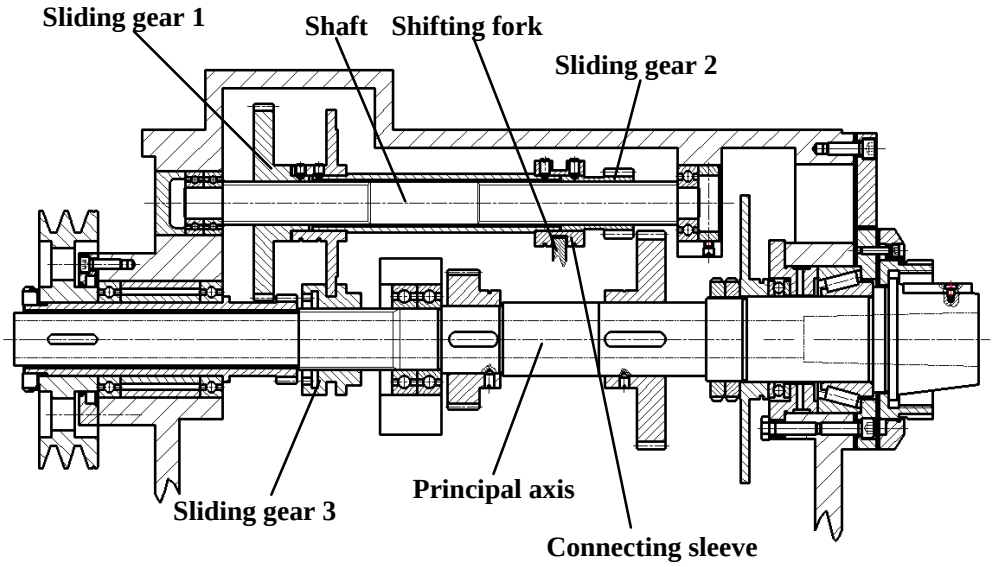

FIG. 1 Main transmission diagram of C616 lathe

2.1 Principle of sliding gear transmission mechanism based on bearing

It is found that the basic reason for the problems of low transmission accuracy, high noise and unstable meshing of sliding gear structure is that there is clearance between sliding gear and fork fixed on the body and sliding friction is easy to occur when the transmission system works. Although many manufacturers have treated the surfaces of fork and gear accordingly, the effect is still unsatisfactory ,and the cost of transmission system is increased. After researching the transmission mode and working environment of common sliding gears, it is found that the movement relationship between the gears and the fork can be replaced by the relative rotation of the inner and outer rings of the bearing. Therefore, in this paper, a deep groove ball bearing is installed between the fork and the gear to rotate the inner rings of the bearing with the rotation of the sliding gears. The outer ring of the bearing is fixed with the fork. The fork drives the sliding gear to move on the spline shaft by the force acting on the bearing. The sliding friction between the gear and the fork in the traditional gear sliding

mechanism is transformed into rolling friction in the bearing, which greatly prolongs the service life of each part and improves the accuracy of the sliding gear transmission.

2.2 Design of Gear Sliding Transmission Based on Bearing

The assembly diagram of the gear sliding mechanism designed in this paper is shown in Fig. 2. The gear sliding transmission mechanism needs to be installed on the spline sleeve on the spline shaft. The spline sleeve can move on the spline shaft. The sliding gear needs to be assembled on the spline sleeve and positioned. In addition, deep groove ball bearings are also required on spline sleeves. In the traditional gear sliding mechanism, the way of directly shifting gears with shifting fork is changed to clamp the outer ring of deep groove ball bearing with shifting fork and clamping plate. When the spline shaft is in operation, the inner ring of the bearing and the parts on the shaft rotate. But the fork and clamping plate of the bearing outer ring and the fixed bearing outer ring are fixed. By using the working characteristics of the bearing itself, a series of problems caused by the contact between the fork and the gear are avoided.

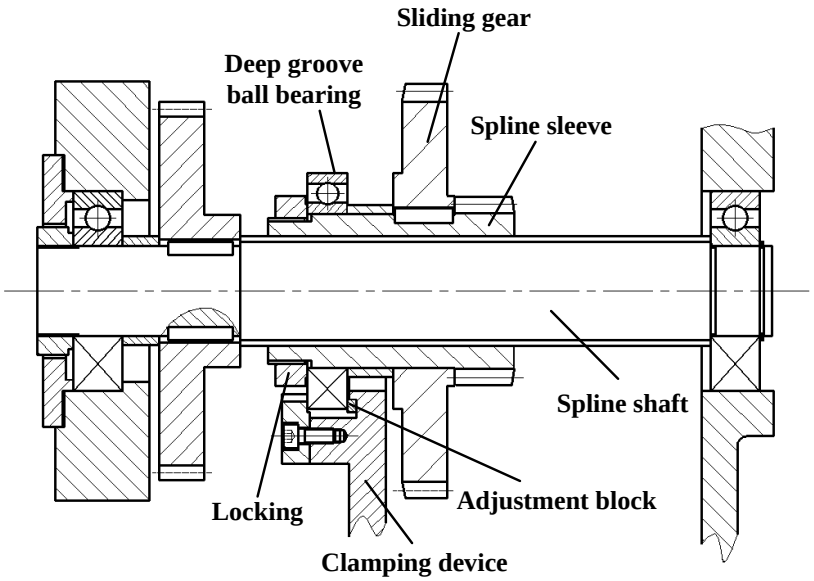

FIG. 2 Assembly drawing of gear sliding mechanism

2.3 Design of Lock-in Device

In many machine tools, there is no sliding gear position locking device in the gear sliding transmission mechanism. When oil leakage occurs in the hydraulic circuit or sudden shutdown occurs, the gear slides uncontrollably on the spline shaft, resulting in teeth beating and other accidents. In this paper, the mechanical position automatic locking mechanism is used to lock the gears in the meshing position automatically, so as to prevent the occurrence of teeth beating.

Gear position automatic locking device includes spring, pin, guide end cover and other parts. The assembly drawing is shown in Fig. 3. The device is installed on the gearbox. According to the drawing, springs and pins are set on the gearbox. When the gear slides to the meshing position, the pins pop out under the action of springs and are stuck in the tail hole of the screw convex platform. The screw convex platform is connected to the fork through threads, thus locking the fork and the gear in the meshing position. When shifting is needed, the fork can be separated from the threaded boss by manually operating the gear rod or the hydraulic (pneumatic) cylinder to drive the fork.

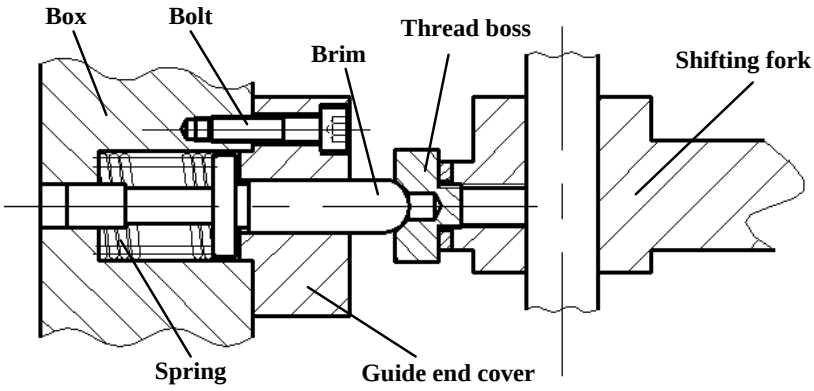

FIG 3 Gear Locking Device Diagram

2.4 Design of Position Detection Device

In order to further improve the transmission accuracy of gear sliding transmission mechanism, the gear meshing position detection device is also designed in this paper. The proximity switch is set on the box body. The proximity switch position should be in the corresponding horizontal position of gear meshing. When the triple or multiple sliding gears are used, the number of the corresponding proximity switches can be increased. When the gear slides to the meshing position, the proximity switch sends out a signal, which makes the gear stop sliding and is fixed by the position automatic locking device. The design of position detection device makes the meshing position of gears accurate and the slip response of gears fast.

3. Application of sliding gear transmission mechanism

The gear sliding transmission mechanism has a wide range of applications, such as machine tool main transmission system speed change, automobile transmission shift, and other use of sliding gears to achieve speed change and other occasions .At present, the gear sliding transmission mechanism designed in this paper has been applied to KVC1400D vertical machining center in a company's intelligent production line. The assembly diagram of the spindle box of the applied vertical machining center is shown in Fig. 4. The fork in the spindle box of the machine is driven by hydraulic system. In order to prevent the fork from rotating around the hydraulic piston shaft, the guiding and positioning axle is designed in this paper, which further guarantees the transmission accuracy of the spindle box transmission system and makes the mechanism more reliable.

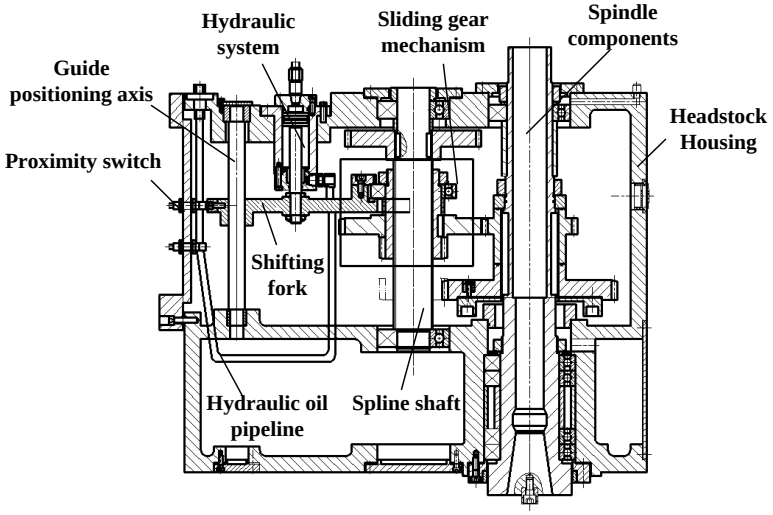

FIG 4 Spindle Box Assembly Drawing of Vertical Machining Center

4. Conclusion

In this paper, the slip mode of sliding gear is innovatively designed by using ordinary deep groove ball bearing parts. By using the relative rotation of the inner and outer rings of the bearing, the direct contact between the shifting fork and the gear in the gear sliding transmission mechanism is avoided. The sliding gear transmission mechanism designed in this paper is applied to a vertical machining center of a company. The experimental results show that the innovative design of the sliding gear transmission mechanism has the advantages of high transmission accuracy, stable speed change and low noise compared with the original one.

Acknowledgements

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