

Research on the tool holder mode in high speed machining

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Abstract: High speed machining technology can improve the processing efficiency and precision, but also reduce the processing cost. Therefore, the technology is widely regarded in the industry. With the extensive application of high-speed machining technology, high-speed tool system has higher and higher requirements on the tool chuck. At present, in high speed precision machining, several new kinds of clip heads are as long as there are heat shrinkage tool-holder, high-precision spring chuck, hydraulic tool-holder, and the three-rib deformation chuck. Among them, the heat shrinkage tool-holder has the advantages of high precision, high clamping force, high bending rigidity and dynamic balance, etc., which are widely used. Therefore, it is of great significance to research the new requirements of the machining tool system. In order to adapt to the requirement of high speed machining precision machining technology, this paper expounds the common tool holder technology of high precision machining, and proposes how to select correctly tool clamping system in practice. The characteristics and existing problems are analyzed in the tool clamping system.

Keywords: tool holder, high speed machining, characteristic research;

1. Introduction

In recent years, the application of CNC machine tool has been popularized, and high speed machining technology is developing rapidly [1]. In order to achieve high speed, high efficiency, and high precision machining, all kinds of high speed machining centre spindle speed is not only as high as 10000-100000 r/min, and the spindle rotation accuracy is high. Its radial run-out is generally not more than 2 μm . In addition to selecting high performance machining tools, a high performance tool clamping system is also selected.

In the application of high speed machining technology, it is often ignored how to select the tool holder method. This could mean a qualified parts and production of waste. The advantages and disadvantages of high speed machining depend greatly on the design of the tool clamping system. Therefore, it is very important to choose the tool clamping system which adapts to the high speed machining. The precision and reliability of the cutter holder should be highly regarded. The paper introduces the working principle and characteristics of heat shrinkage tool-holder with high speed machining, high precision spring chuck, hydraulic tool holder, static pressure expansion chuck and three-rib deformation chuck.

2. Technical analysis

2.1. Heat shrinkage tool-holder

The so-called hot tool holder is one of the methods used to realize the holder of milling cutter, drill bit, reamer and other kinds of tools. The clamping system is composed of the hilt monomer, and the center



of the hilt has a tool mounting hole [2]. Use the heating device to heat the tool installation part of the handle, and then insert the tool into it after the tool mounting hole expands. After cooling to normal temperature, the tool installation hole shrinks and holds the cutter, as shown in Figure 1.

Heat shrinkage tool-holder is a hot topic in recent years. The technology can provide the main reason is that hot charging handle is nearly perfect the handle. The handle of the radial run-out is small and large clamping force, and the use of this handle can keep the position of the machining tool precision, and can obtain high machining accuracy, surface roughness and long service life of machining tools.



Figure 1. Heat shrinkage tool-holder

The clamping principle of the tool system is to heat the shank of the tool by means of induction heating, as shown in Figure 2. When the temperature reaches $315^{\circ}\text{C} \sim 425^{\circ}\text{C}$, the minus tolerance shank diameter can fully expanded to tool petiole insertion. Insert the tool shank into the inner hole, then cool the handle and tighten the tool with the grip of the handle. The hot mounted handle has the following advantages. 1) the shape of the head is slender. 2) high pendulum precision. 3) clamping force. 4) can adapt to high speed rotation. 5) facilitate access to workpieces. 6) internal cooling can be adopted.

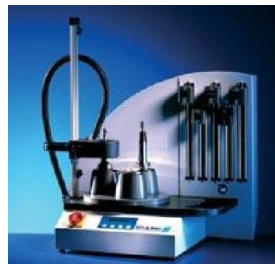


Figure 2. Induction heating device

2.2. Spring chuck

The spring chuck is a kind of cylindrical fixture used to hold a bit, or a milling cutter in a milling machine, as shown in Figure 3. It is a fixed device for fixing parts that need to be reworked.



Figure 3. Spring chuck

Before installing the spring chuck, the chuck must be loaded into the lock nut. The locking nut with the spring clip is gently screwed to the handle, the rod or the spindle. Be sure to clean the threaded part of the spring chuck, locking nut, the locating surface and the cone [3].

The working principle of the spring chuck is divided into four main parts, which are the spinning nut, pressing into the sleeve, reducing the inner diameter of the sleeve, and holding the cutter. Factors affecting the holder accuracy include the chuck body bore precision, in addition to accuracy of the sleeve, the sleeve outer cone accuracy, the accuracy of the holding hole and the thread accuracy. The nut and the sleeve contact surface accuracy and the sleeve are also important.



Figure 4. Working principle of spring chuck

The pressure of normal spring chuck is shown in Figure 4a. In the process of lock nut, the contact surface of the nut and sleeve will be relative. This not only causes the sleeve to be stressed, but also the contact surface to wear. It is difficult to obtain or maintain good holder accuracy. Japanese companies design and produce high-precision spring chuck, which is pressed into Figure 4b. The nut is divided into inner and outer parts, and the ball bearings are installed in the center. When the nut contacts the sleeve, the inner part of the nut stops rotating, and there is no relative motion between the sleeves. The locking force of the nut is completely transformed into the pressure of the sleeve, which allows the holder to get a larger clamping force and a higher clamping precision.

2.3. Hydraulic tool-holder

The hydraulic tool-holder can provide sufficient rigidity and dynamic balance, and can make the tool shank and the spindle of the holder head into a straight line, as shown in Figure 5. Hydraulic tool-holder can only hold round handle tool, and is not suitable for holding non-round handle cutter. If you use a hydraulic shank to hold a non-round shank tool, it will cause uneven deformation of the inner sleeve. If the use of time is too long, it is difficult to firmly clamp the tool [4].



Figure 5. Hydraulic tool-holder

Hydraulic tool-holder is a widely used tool holder. The kind of shank holder method is different from the traditional shank system, and is tighten only use a pressure bolt. When the bolt is tightened, it pushes the piston seal to generate a hydraulic oil pressure in the shank. The pressure is evenly transmitted from the circumferential direction to the steel expansion sleeve, which then clamps the tool, as shown in Figure 6. The tool clamping system can make the radial run-out error accuracy and repeat positioning accuracy controlled below $3\mu\text{m}$. Due to the presence of high-pressure oil pressure in the shank, the built-in oil chamber structure and high pressure oil greatly increase the structural damping when the tool is clamped, which can effectively prevent the vibration of the tool and the spindle of the machine tool.

Hydraulic tool-holder is widely used in automobile manufacturing, electronics, mold, machinery and other departments, the current major equipment providers are Schunk, Sandvik, Kennametal and other internationally renowned brands.

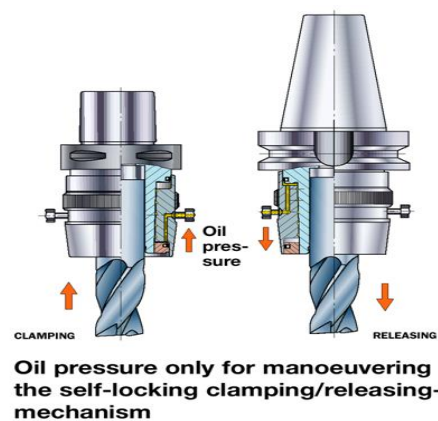


Figure 6. Hydraulic tool-holder working principle

2.4. The three-rib deformation chuck

The three-rib deformation chuck is used to clamp the cutter with its own deformation force [5-6]. The chuck is triangular in free state, as shown in Fig. 7a. The diameter of the inner circle of the triangular shape is less than the diameter of the shank of the holder, and a hydraulic pressure force device is used to apply external forces to the holder head, which can transform the clip head into a round hole, as shown in Fig. 7b. The diameter of the hole is slightly larger than the diameter of the shank, and the tool shank can be successfully inserted into the holder hole, as shown in Fig. 7c. Then remove the external force, the inner hole is redrawn into a triangular shape, the handle is tightened with a strong elastic resilience, as shown in Fig. 7d.

This kind of chuck has compact structure and good symmetry. Accuracy is high, holder rotation accuracy $\leq 3 \mu\text{m}$. Compared with the heat shrinkage tool-holder, tool handle is simple, and for different expansion coefficient of carbide handle and high-speed steel shank can be applied.

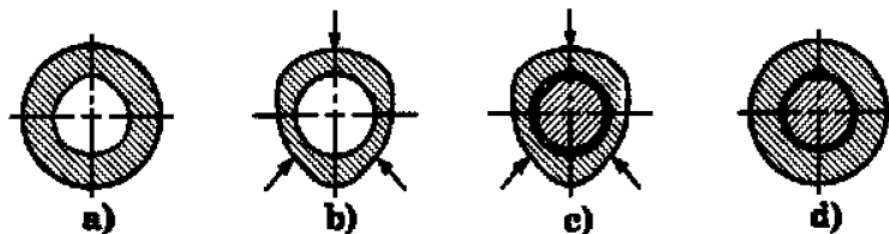


Figure 7. Working principle diagram of three rib deformation chuck

Through the previous analysis, the comparison of the properties of spring chuck, hydraulic holder, heat shrinkage tool-holder and three-rib deformation is shown in Table 1.

Table 1. The characteristics of various holder comparisons

Type	Milling Chuck	Spring chuck	Hydraulic tool-holder	Heat shrinkage tool-holder
Accuracy	0.01	0.003	0.0003	0.0005
Radial jump	0.01mm~0.02mm	0.01mm~0.02mm	0.002mm~0.005mm	0.002mm~0.005mm
Outer diameter	Very thick	Thinner	General	Very thin
Overhang length	Long	Long	Long	The longest
Torque	Good	Better	Best	Best

transmission				
Rigidity	Good	Better	good	Best
Blades material	High-speed steel, carbide	High-speed steel, carbide	High-speed steel, carbide	Carbide
Clamping force	The strongest	General	General	General
Dangerous	No	No	No	Yes
High-speed machining	Fit	Fit	Fit	Fit
Operability	Good	Better	Best	Very poor

3. Summary

At present, the new high-speed precision tool chuck is heat shrinkage tool-holder, high-precision spring chuck, hydraulic tool-holder and the three-rib deformation chuck in the most advanced high-tech CNC machine tool system. Although its share of value is small, it is an important tool system for connecting machine tool spindles and tools, which directly affects the quality of the finished product. Therefore, increasing the high-speed machining tool chuck theoretical research and manufacturing base for research is especially necessary.

4. References

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