

Where will Computer Numerical Control Machines Go?

Servo Motor



Figure 1: A CNC machine is operating.

Scroll Compressor

At present, the development of Computer Numerical Control (CNC) machines with each passing day, characteristics of high-speed, high-precision, complex, intelligent, open, parallel drive, network, extreme, green have become the trend and direction.

High Speed

With the rapid development of automobile, national defense, aviation, aerospace and other industries, as well as the application of new materials such as aluminum alloy, the high speed of CNC machine processing is becoming critical.

* Spindle Speed

The machine adopts electric spindle (built-in spindle motor), and the maximum spindle speed up to 200,000 r/min;

*** Feeding Rate**

When the resolution is $0.01\mu\text{m}$, the maximum feed rate can reach 240m/min and the complex surface can be processed accurately.

*** Operation Speed**

The rapid development of microprocessors lays the foundation for the high speed and high precision of the computer numerical control system. Thanks to the high speed of operation, the feeding speed of $24 \sim 240\text{m/min}$ can be obtained when the resolution is $0.1\mu\text{m}$ and $0.01\mu\text{m}$.

*** Tool Changing Speed**

At present, the tool changing time is generally about 1s , and the short is 0.5s . Chiron, a German company, designed the tool storage as a basket style, with the spindle as the axis, and the tool is arranged in the circle, and the changing time is only 0.9s .

High Precision

The precision requirements of CNC machines are not limited to the static geometric accuracy, the motion accuracy, thermal deformation and vibration monitoring and compensation of machine tools attracted more and more attention.

*** Improve the Control Accuracy of CNC System**

Interpolation type in high-speed machines is adopted to realize continuous feed with a small program section, so that the CNC control unit is refined, and high resolution position detection device is adopted to improve the position detection accuracy. The position servo system adopts feedforward control and nonlinear control.

*** Error Compensation Technology**

The thermal deformation error and space error of the equipment are comprehensively compensated by reverse gap compensation, screw pitch error compensation and error compensation in tools. The results show that the application of the comprehensive error compensation technology can reduce the error by $60\% \sim 80\%$.

*** Accuracy Improvement**

The mesh is used to check and improve the motion trajectory accuracy of the machining center. And the machining accuracy is predicted to ensure the positioning accuracy and repeated positioning accuracy, ensuring long-term and stable operation, as well as

completing a variety of processing tasks under different operating conditions, and the processing quality of parts.



Figure 2: A CNC machining process.

Complex Function

The Complex machine is to achieve from the blank to the finished product of a variety of factors processing. People use complex machines for processing, thus reducing the time of workpiece loading and unloading, changing and adjusting the tool in the process and error.

Therefore, it improves the processing precision of parts, shortens the product manufacturing cycle, strengthens the production efficiency and manufacturers' market reaction ability, compared with the traditional process of dispersed production method.

The complex processing process also leads to the development of modular and multi-axis machine tools.

With the continuous improvement of modern machining requirements, a large number of multi-axis CNC machines are becoming increasingly popular among major enterprises.

Intelligent Control

With the development of artificial intelligence technology, in order to meet the development needs of manufacturing flexibility and manufacturing automation, the intelligence degree of CNC machines is constantly improving. It is embodied in the following aspects.

* **Process Adaptive Control Technology**

Monitoring the cutting force in the process of machining, spindle and the feed motor power, the information such as current, voltage, and using the traditional or modern algorithm, can identify by ferreting out the stress of the cutting tools, wear and tear, damage state and the stability of the machine tool processing state.

According to the state of real-time adjusting processing parameters (spindle speed, feed rate) and processing orders, users can improve the safety of the equipment operation.

* **Intelligent Optimization and Selection of Machining Parameters**

The intelligent optimization and selector of machining parameters based on an expert system or model is constructed by a modern intelligent method. The optimized processing parameters can be obtained based on it, so as to improve the programming efficiency and the processing technology level, and shorten the production preparation time.

* **Intelligent Fault Self-Diagnosis and Self-Repair Technology**

According to the existing fault information, the modern intelligent method is applied to realize the fast and accurate fault location.

* **Intelligent Fault Playback and Fault Simulation Technology**

It can record all kinds of information of the system completely, replay and simulate all kinds of mistakes and accidents of CNC machines to determine the causes of errors, find out the solution to the problem, and accumulate production experience.

* **Intelligent AC Servo Drive**

The intelligent servo system can automatically identify the load and automatically adjust the parameters, including intelligent spindle AC drive device and intelligent feeding servo device.

The drive device can automatically identify the inertia of the motor and load, and

automatically optimize and adjust the parameters of the control system, so that the drive system can get the best operation.



Figure 3: SIEMENS Servo Motor 1FK6080-6AF71-1AG2

*** Intelligent 4M CNC System**

During the manufacturing process, the integration of machining and detection is an effective way to achieve fast manufacturing, fast detection and fast response. Measurement, Modelling, Manufacturing and Manipulator (4M) are integrated into one system to achieve information sharing.

Parallel Drive

As for traditional machine tools, the mass of series mechanism moving parts is large, the system stiffness is low, the tool can only feed along the fixed guide rail, the operating degree of freedom is low, and the equipment processing flexibility and mobility are not enough. The parallel kinematic machine tool overcomes these defects.

The machine tool spindle (moving platform) and the machine base (static platform) are driven by a multi-bar parallel connection mechanism, and the platform supported by the rod system obtains the corresponding freedom of movement.

It can realize multi-coordinate CNC machining, assembly and measurement of a variety of functions, and meet the processing of complex special parts. It has the advantages of high modularity, lightweight and fast speed of modern robots.

As a new type of processing equipment, parallel kinematic machine tools have become an important research direction of current machine tool technology, and have been highly valued by the international machine tool industry.

It is considered as "the most significant progress in the machine tool industry since the invention of numerical control technology" and "the new generation of numerical control processing equipment in the 21st century".

Networking of Information Interaction

For enterprises facing fierce competition, it is very important to make CNC machine tools with two-way, high-speed network communication function, which ensures that the flow of information in the workshop between the various departments unimpeded.

It can not only realize the sharing of network resources, as well as the remote monitoring, control, training, teaching, management of CNC machine tools, and digital services of CNC equipment (remote diagnosis and maintenance of CNC machine tools, etc.).

New Type of Functional Components

In order to improve the performance of CNC machine tools in various aspects, the application of new functional components with high precision and high reliability is inevitable.

* High-Frequency Motorized Spindle

The high-frequency motorized spindle is the integration of high frequency motor and

spindle components, with small volume, high speed, stepless speed regulation, has been widely used in a variety of new CNC machine tools.

* **Linear Motor**

In recent years, linear motors have been widely used. Although its price is higher than the traditional servo system, due to the application of load change disturbance, thermal deformation compensation, magnetic isolation and protection, the mechanical transmission structure has been simplified, and the dynamic performance of machine tools has been improved.

For example, **Siemens** 1FN1 series three-phase AC permanent magnet synchronous linear motor has been widely used in high-speed milling machines, machining centers, grinding machines, parallel machine tools and machine tools requiring high dynamic performance and motion precision, etc.

* **Motorized Lead Screw**

The electric ball screw is the integration of servo motor and lead screw, which can greatly simplify the structure of CNC machine tools, with fewer transmission links, and compact structure.



Figure 4: A motorized lead screw.

High Reliability

In order to ensure the high reliability of CNC machine tools, it is necessary to carefully design the system, strict manufacturing and clear reliability objectives and analyze the failure mode and find the weak links through maintenance.

Green Process

With the increasingly strict environmental and resource constraints, the manufacturing and processing optimization is becoming more and more important.

Therefore, in recent years, without or less use of coolant, to achieve dry cutting, semi-dry cutting energy-saving and environmental protection machine tools has been appearing, and in continuous development.

In the 21st century, the general trend of green manufacturing will accelerate the development of various energy-saving and environment-friendly machine tools and occupy more world markets.

Application of Multimedia Technology

Multimedia technology integrates computer, audio and video technology and communication technology, which makes the computer have the ability to process sound, text, image and video information, so it also puts forward the requirements of graphical user interface.

Reasonable humanized user interface is helpful for great non-expert users, and people can operate through the window and menu.

It is advantageous for the blueprint programming and rapid programming, 3 D color three-dimensional dynamic graphical display, dynamic tracking and graphic simulation and graphic simulation, the different views and the direction show the realization of the function of scaling.

In addition, the application of multimedia technology in the field of numerical control technology can be integrated information processing, intelligent, applied in the real-time monitoring system and production site equipment fault diagnosis, production process parameters monitoring, so it has great application value.

Servo Motor for CNC Machine

In the application of CNC machine tools, the **servo** motor is an important part of the CNC servo system, and the speed and trajectory control of the executive components.

AC servo motor drive is a new type of servo system, which is also a new trend in the current machine tool feed drive system. The system overcomes the shortcomings of the DC drive system, such as frequent maintenance of the motor brush and the commutator, large size of the motor and operating limitations. It can produce ideal torque in a wide range of speed control, simple structure, reliable operation, for CNC machine tools and other feed drive systems for precise position control. The working principle of the AC servo motor is similar to that of a two-phase asynchronous motor.