HYDRAULIC NETWORK REMOTE CONTROL SYSTEM OF COMPUTER NUMERICAL CONTROL MILLING MACHINE

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ABSTRACT*: To improve the utilization of domestic computer numerical control (CNC) milling machine, give full play to the use efficiency. Based on the hydraulic system design technology, the remote design of the hydraulic system was realized with powerful analysis and reasoning function of expert system and the convenience features of the Internet. The results show that the machine data sharing was effectively realized by embedding the modules of on-site server accessing the NC kernel into the server program. In addition, the unattended server function was realized. The result shows that the labor intensity of the operator was reduced, and the efficiency was improved. It is concluded that the hydraulic network remote control system of CNC milling machine can effectively reduce the labor intensity and improve work efficiency.*
KEYWORDS*: CNC milling machine, hydraulic system, remote control system*

1   INTRODUCTION

Modern machine tool numerical control technology was a new machine tool control technology developed in the 1970s. It is a kind of new and high technology which is formed by the latest achievements of microelectronic technology, computer technology, modern control technology, sensor detection technology, information processing technology, network communication technology and mechanical manufacturing technology and is one of the core technologies of advanced manufacturing technology. With the rapid development of computer technology, communication technology, network technology and information technology, the requirements of CNC machine tools are getting higher and higher. They are gradually developing in the direction of networking and intelligence (Deus et al., 2015). In addition, as the globalization of the world economy progresses rapidly and the energy shortage and theimpact of the global financial crisis deepen, the market competition in the equipment manufacturing industry becomes even more intense. Therefore, the enterprises using CNC machine tools not only need to quickly respond to the market, reduce production costs, but also to ensure and improve product quality. Today, the network has achieved rapid development, in addition to the traditional manufacturing technology, the remote monitoring system of CNC machine tool is adopted. This advanced manufacturing technology improves the production efficiency and product quality of equipment manufacturers. The remote control system of CNC machine tool is the basis for achieving network manufacturing and network troubleshooting and maintenance, and is also one of the inevitable trend of the development of CNC machine tools. On the one hand, it can realize the networked and intelligent CNC machine tools. On the other hand, through the network monitoring, the virtual presence, remote diagnosis and remote processing of remote maintenance for CNC machine tools can be achieved (Takahashi et al., 2015).

2   THEORETICAL RESEARCH OF REMOTE CONTROL SYSTEM

Remote control system is an advanced technology based on communication technology. The development of communication technology improves the development of remote control technology. Almost all remote control systems can be divided into remote monitoring terminal system, long-distance data transmission system, field equipment monitoring and control system (Sakaino et al., 2017). Each part carries out the division of labor and cooperation, and realizes the remote control of the equipment. Remote control system model is shown in figure 1.
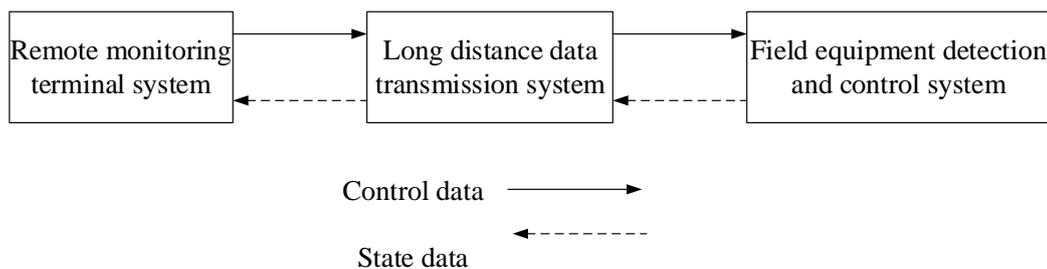
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┌─────────────────┐      ┌─────────────────┐      ┌─────────────────┐
│ Remote monitoring│ ───▶ │ Long distance data│ ───▶ │Field equipment detection│
│ terminal system │ ◀--- │transmission system│ ◀--- │ and control system│
└─────────────────┘      └─────────────────┘      └─────────────────┘
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Control data ──────▶

State data ◀ - - - - -

Figure 1.Model of remote control system

2.1.Remote monitoring terminal system

Remote monitoring terminal system (hereinafter referred to as monitoring terminal or monitoring terminal) is the interface that the user interacts with the field device. From a functional point of view, it mainly includes terminal display of remote device status, control commands and parameter input, necessary processing of command parameters and status data, and other operations. At present, remote control terminal software technology based on microcomputer has developed rapidly due to the wide application and low price of the microcomputer. Meanwhile, the remote control computer is far away from the industrial site. Therefore, the remote control terminal software technology based on the microcomputer has developed rapidly, the microcomputer has become the main operating platform for remote monitoring terminal system (Yu et al., 2015).

2.2.Long-distance data transmission system

As a long-distance control information transmission channel, long-distance data transmission system can carry out various types of control data transmission. The purpose of the transmission system is to transmit the status information of the equipment to the monitoring terminal as soon as possible. Therefore, the operator can determine the next step (such as sending control commands through the transmission system) through the understand of the field equipment. In addition, the control information of the monitoring terminal needs to be transmitted to the control host in the field so as to control the equipment. Of course, the video image plays an important role in some remote monitoring applications. However, the amount of image information is particularly large, the quality of the transmission is high. There is no interruption. In addition, there are certain requirements on the communication line. At present, the video and audio signals and data signals are generally transmitted separately, so that they occupy different channels, wave bands or frequency bands. For example, when using ISDN mode (Grigor'ev et al., 2015; Faris et al., 2015), the 2B channel of ISDN is used to transmit video and audio signals. D channel is used to transmit data information. As the bandwidth and reliability of the Internet increase, the remote control based on Internet has even more promise. A communication system usually consists of communication media, communication protocol, communication software, hardware system and so on. Table 1 shows some existing network standards that the transmission system can adopt.

Table 1. Network communication and protocol

Content	Standard example
Physical connection	Telephone line, twisted pair, DDN, optical fiber, coaxial cable, microwave
Underlying agreement	Ethernet, ISDN, ATM
Basic application protocol	TCP/IP, PPP, SLIP
Advanced communication protocol	HTTP
Network operating system	WINDOWS, UNIX, LINUX

2.3.Field equipment monitoring and control system

Field equipment monitoring and control system is referred to as on-site monitoring system, is a direct on-site monitoring and control equipment system. The main task is to control the equipment according to the control data of the monitoring terminal and monitor the status of the equipment at the same time. In addition, the necessary analysis is achieved. Then, these states are feedback to the monitoring terminal through the transmission channel. Field monitoring system is actually a computer control system. It is a control system with computer as the center, which integrates field control, management and data collection (Yang et al., 2016; Nedic et al., 2015).

Remote control is a computer controlled by a master computer on the network from another

controlled terminal. Remote does not refer to long-distance, and it usually refers to the control of remote computers over the network.

The principle of the remote control system is that the user connects to the network and sends the client's authentication information and the request to connect with the remote host through the remote access client program. The server program of the remote host verifies the client's identity. If the authentication passes, the user sends the information to verify that the connection has been established.

At this point, the user can monitor or send commands to the remote host through the client program. The server executes these instructions, and the screen refresh data to the client program. Therefore, the client program displays the host's screen and other information to the user through the relevant operations, so that the user is like personally working on a remote host. If the user does not pass authentication, then there is no connection with the user. Therefore, the user cannot control the remote host.

2.4. Visual Basic 6.0 introduction

Visual Basic is a Windows application development language introduced by Microsoft Corporation in 1991. In just a few short years, it has become a popular Windows programming language and radically changed the traditional programming model. Therefore, the design of Windows applications is greatly simplified. Its appearance is regarded as a "shocking miracle" by the computer world. Visual Basic is a visual, object-oriented and event-driven structured high-level programming language. It uses APIs inside Windows and technologies like dynamic link library (DLL), dynamic data exchange (DDE), object linking and embedding (OLE), open database connectivity (ODBC). This can efficiently and quickly develop the application with powerful, graphical expression based on the Windows environment (Yu et al., 2015).

Traditional programming language designs the user interface through programming code. Developers cannot see the actual display interface in the design process. He can only see it when it is compiled to run the program. If the developer wants to modify the interface effect, he will still have to go back to the program, which affects the efficiency

of software development. However, VB provides visual design tools. Developers only need to screen the layout according to the requirements of the design, and draw various components on the screen with the tools provided by the system. It is commonly known as controls. In addition, the properties of these controls are set, that is, the design of the interface can be completed. This "what we see is what we get" approach greatly facilitates interface design.

Visual Basic has some of the features of the object-oriented programming (OOP) language. However, it is different from programming languages such as Java and VC ++. The latter object consists of program code and data, and is an abstract concept. However, Visual Basic encapsulates the program and data as an object and gives each object the proper attributes. As a result, the object has become a real thing and become more specific and intuitive. In addition, Visual Basic can also be used as a way to design objects.

3 SOFTWARE DESIGN OF REMOTE CONTROL SYSTEM

Client / server model is an advanced computing model, but also the development of the mainstream in the future. The greatest feature of this model is that the intelligence, resources and computing power of the client and server are used to perform a specific task (Chen et al., 2015).

### 2.5. Client /server structure (C/S structure) and features

The so-called "C/S" refers to client/server. The vast majority of network applications can be divided into the following four levels: presentation layer, transaction layer, data logic layer and data storage layer. C/S mode is a two- layer or three-layer system. In the two- layer C/S mode (as shown in figure 2), the presentation and transaction layers are placed on the client side, while the data logic and data storage layer are placed on the server side. Server is a multi-client application management data. However, the client program sends requests and analyzes the data received from the server, which is a "fat client" and "thin server" mode. The working process is shown in figure 3.
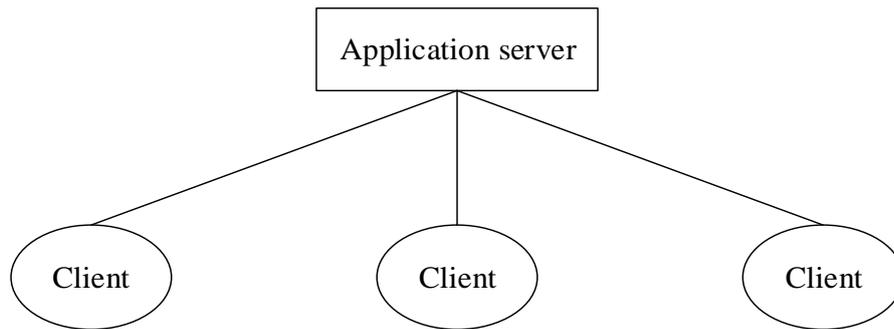
Figure 2. Two-layer C/S mode

The basic idea of a client/server system is that we can centrally store the information resources in a single place. A data set is generally stored in a database and delivered to each other according to the requests of other people or machines. A key part of the client/server overview is that the information is centrally stored. Therefore, managers can easily change the information, and then the modified information is distributed to consumers. The various elements are gathered. The infor-

mation warehouse and the software used to deliver the information, as well as the machine where the information and software are located are collectively called a "server." However, for software that resides on remote machines, they need to communicate with the server and retrieve the information. The information is processed appropriately and displayed on a remote machine. These are called clients.
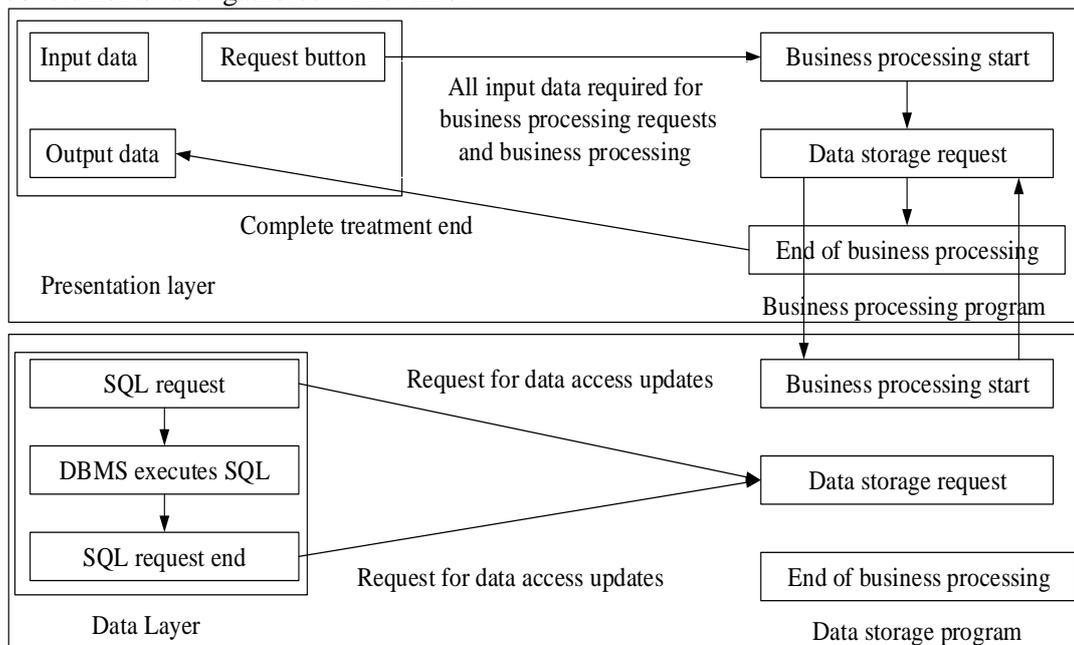
Figure 3. The general processing flow of two-layer C/S mode

2.6. Program design of data transfer between PC1 and NC

Using COM server and COM class library, the program of data transmission between PC1 and NC has been programmed through PC1. Therefore, the data communication with the core NCK of NUM CNC system is realized.

Component object model (COM) is an object model with component as a publishing unit. Based on this model, various software components can interact in a unified way. The so-called component object is actually a service or interface that is predefined and can perform a certain function. To

ensure that these component objects co-exist and interact with applications and other component objects, there is a need to develop a specification that will allow those component objects to work in a uniform and standard way. COM is such a binary specification and it has nothing to do with the source code. In this way, COM objects can communicate with each other even if they are created in different programming languages and run on different process spaces and different operating system platforms. COM is both a specification and an implementation. In the form of the COM library (OLE32.DLL and OLEAut32.DLL), it provides a standard interface to access the core

functions of the COM object and a set of API functions, which are used to create and manage COM objects.

CNC system divides the module according to different functions. These modules are packaged by COM component technology and the corresponding NC kernel APIs. As a result, each module has a unified COM component interface. Thus, the CNC modules of different suppliers can be exchanged, so that customization is possible (Vázquez et al., 2015). The scattered COM components are combined into a CNC application system that meets the requirements of the user and is implemented by the system configuration software. System configuration software can be used according to the user's choice. The COM component in the COM component library is instantiated and assembled into an application system with a specific function. When users' needs change, it is possible to replace the corresponding COM components or add some required functions of COM components through system configuration software to adapt to the needs change. The structure of COM general class library is shown in figure 4.
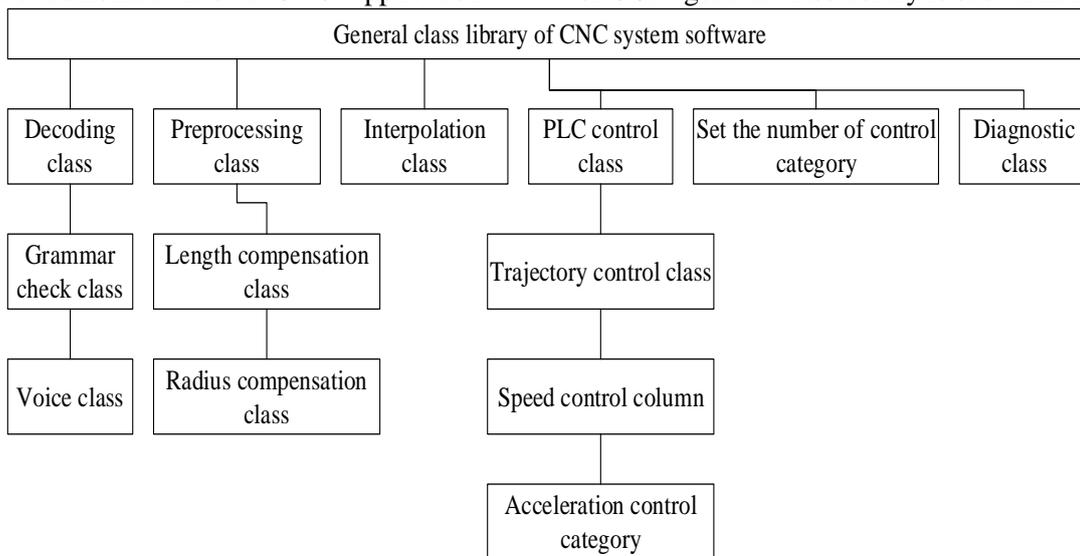

Figure 4. Structure model of universal library of NC software

Applications that use COM component architecture have a number of advantages:

Application customization: Different application features are implemented by replacing COM component objects that have the same COM component interface.

Fast program architecture: The application development cycle is shortened by selecting the required components from the component library and using the applications they need to quickly assemble the architecture.

Dynamic program architecture: Without recompiling, the corresponding components can be displaced or replaced dynamically. At the same time, it dynamically changes the function of the application. It shows that COM component technology is very suitable for the development of open CNC application systems.

2.7. Data transmission program design between main control room (PC2) and PC1

Winsock is an open network programming interface developed by Berkeley sockets that supports multiple protocols and is the standard for Windows network programming. Socket is originally a network communication interface developed by the University of California, Berkeley, for the UNIX operating system. With the widespread use of the UNIX operating system, socket becomes one of the most popular network communication application interfaces. Socket is the cornerstone of communication, and it is the basic operating unit of network communication that supports TCP/IP protocol. A socket can be seen as an endpoint for two-way communication between different hosts, and each network dialogue consists of two endpoints: local host (or process) and remote host (or process). It forms a programming interface between a single host and a whole network. The socket is present in the communication domain. A communication domain is an abstract concept introduced to deal with common threads through socket communication. The socket usually exchanges data with the socket in the same domain, and the Winsock specification supports a single communication domain, that is, the Internet domain. Various processes use this domain to communicate with each other by a TCP/IP protocol family. The socket can be classified according to the nature of the communication, which is visible to the user. Applications are generally com-

municated only in the same type of socket. However, as long as the underlying communication protocol is allowed, the different types of sockets can also be communicated. Currently, users can use two sockets, stream sockets and datagram sockets. Stream socket provides bidirectional, non-repetitive and free boundary data stream ser-

vice. Datagram socket supports bidirectional data streams. However, its reliability, orderliness and non-repeatability cannot be guaranteed., orderly and non-repetitive. Stream and datagram socket programming timing diagram are shown in figure 5.
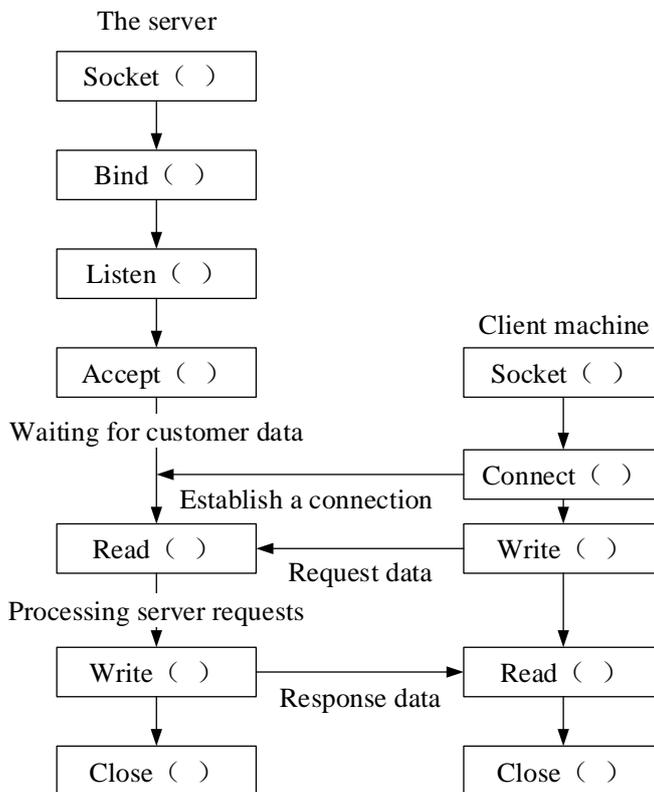

Figure 5. Sequence diagram of stream socket programming

The respective data communication between the two parts of PC1 and NC, PC2 and PC1 is designed and realized. However, the PC1 end of the field server still needs to be operated by the workers. In order to implement unmanned operations at the PC1 end, two parts of the program need to be integrated.

The two part of the program integrated design is based on the communication function of NUM1020 NC system, that is, the mode of master and slave transmission. The COM server is also based on this transmission mode. The two parts of the program are integrated with the two parts of the distributed server - end program and the client - end program, that is, the C/S pattern mentioned

earlier. The server program takes into account the functions of listening to the client, responding to client requests, and reading and writing NCK (NC kernel) according to client requests. The communication function of NUM1020 CNC system only has the function of field operation.

4   CASE ANALYSIS

### 2.8. Construction of hardware and software platform

The remote monitoring system is tested in its own local area network. Its network structure diagram is shown in figure 6.
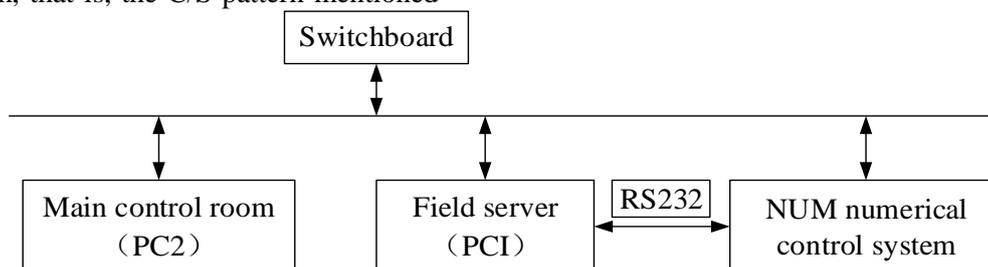
Figure 6. Network structure diagram of LAN test

The construction is divided into two steps: The first step is to make a data line 2 meters for communication between PC1 and NC. Two ends of the serial port line are connected with the COM1 port of the PC1 end and the COM port of the NC end (non Seriallink interface). The next step is to make twisted pair line according to the connection type of PC and switch. Then, two computers are connected through a switch and follow the IP address rules. The IP address of PC1 and PC2 configure is: 192.168.0.3 and 192.168.0.4. The subnet mask is set to 255.255.255.0. The gateway is set to 192.168.0.1. After testing, the hardware experiment platform is built successfully. PC1 and NC are shown in figure 7.
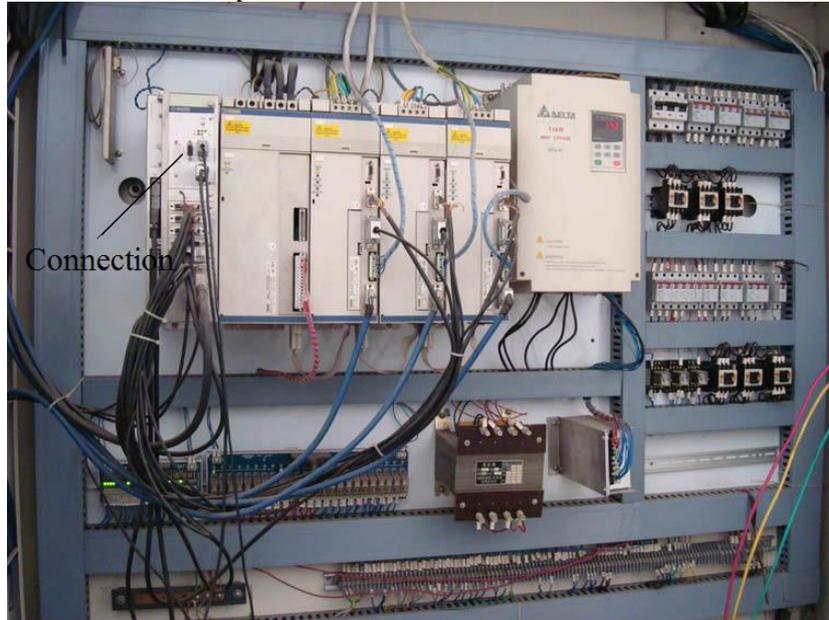
Figure 7. Hardware platform between PC1 and NC

2.9.Software debugging process

In actual operation, the server end does not need human operation after the system is started. Both the client response and the NCK access are done automatically. However, in order to facilitate debugging, capture and observe the data flow, a human operation button is added to the server end.

First, the Server.exe program is set up to run automatically on the field server.

In order to realize the unmanned duty on the server end, the server - end program of the remote control software will run automatically when the server is started. The method is: The startup shortcut of Server.exe is added to the startup item to start all programs.

Secondly, the Client.exe program is run on the main control room server. Then, the user needs to enter the boot interface and click the "connect live server" button. After the "server address input" dialog box is popped, the IP address of the field server is input. Then, the "authentication" dialog box is popped out, and the username and password are entered. After the verification is passed, the main interface of the on-line processing is entered. Next, the user can click on the "program transmission" and "state monitoring" buttons to enter the corresponding functional interface ac-cording to the needs. After the task is completed, the "exit" button is clicked. After pop-up "whether to disconnect from the server" dialog box, the user needs to click "confirm" to disconnect the connection directly to the server.

After clicking the "program transmission" button, it enters the sub interface of the program transmission. The "browse" button is clicked to select the program to be sent, and then the "transfer program" button is clicked. Therefore, the selected parts processing program is transmitted to the storage space of the CNC system through the field server and is saved by the original name. after clicking the "online processing" button, the selected parts processing program is automatically transferred to the on-site server. After the transmission is completed, the client pops up "whether to start the processing" prompt box. After clicking "confirm", the client begins to perform the online processing of the parts.

Through the on-line processing module, the remote transmission of the program is realized and stored in the designated area of the numerical control storage area.

When the parts are started online, we need to see the processing situation in real time. In this program, after clicking the "state monitoring"

button, the status monitoring sub interface is entered (as shown in figure 8). The tool path coordinates are displayed in the table in real time.
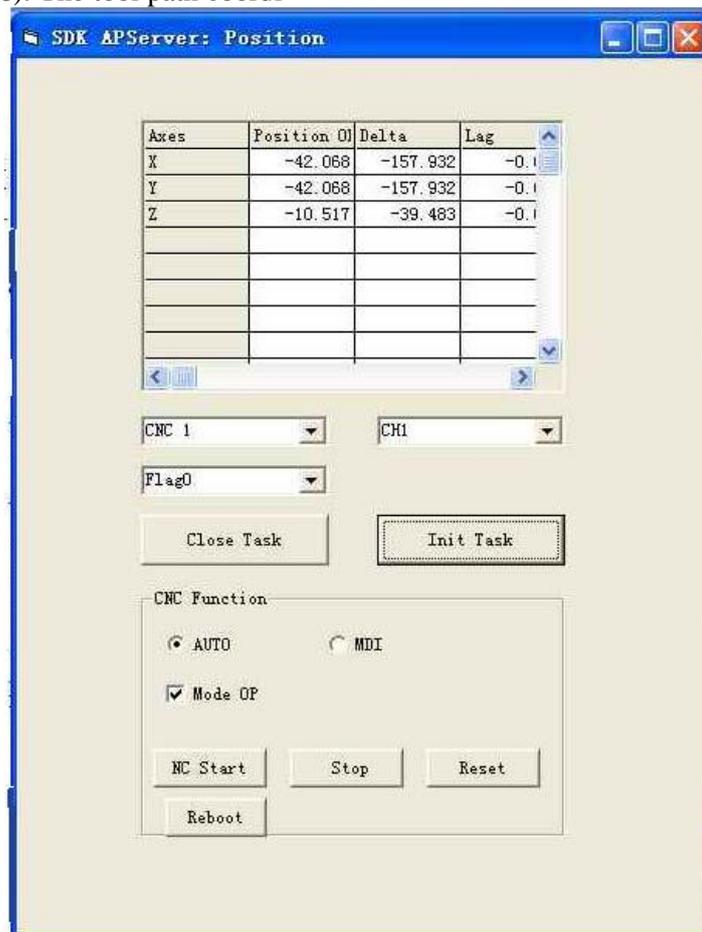

Figure 8. State monitoring interface

5   CONCLUSION

Based on the principle of software development, COM and Winsock technology are used to realize the modular design of program transmission and tool coordinate point display during online processing according to the choice of developing language environment and network mode. At the same time, the server and the client program are written. In addition, the integration of two-way data flow on the server side is achieved.

The Microsoft Visual Basic 6.0 is used as a development tool to communicate with the RS-232 interface of NC machine tools, so as to realize the remote transmission of NC programs and the real-time display of tool coordinate points. In addition, with the help of this software, the operator can only operate on the machine side without operating between the machine and the field server.

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