Motion Control System of NC Turret Punch Feeding Mechanism Based on Motion Control Card

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Abstract. According to the characteristics and requirements of NC turret punch feeding mechanism, the open NC system architecture is constructed based on the mode of PC and motion control card. The structure of hardware system is built with DMC1410 motion control card. The movement pattern of trapezoidal velocity curve and S velocity curve are analyzed. The flow chart and the software module of motion control system of NC turret punch feeding mechanism are presented. Under the support of MFC provided by VS2015 and movement function library provided by DMC1410 motion control card, the software of motion control system is developed.

Introduction

Motion control is the interdisciplinary comprehensive technology and the core of mechanotronics. The position control is usually realized by using singlechip or microcomputer directly, but its peripheral circuit structure is complex and a long development cycle is needed. The requirement of control accuracy and speed becomes more strict and higher, and the traditional control system can not meet the demand to develop product quickly. With the development of control technology, a great variety of motion control cards on the market to meet the requirement of quick speed and high precision which are very suitable for the development of motion control system for special NC equipment.

The motion control system in the paper includes PCI-DMC1410 motion control card based on PCI bus function library, microcomputer, servo motors and so on. According to the planning path and motion parameters, the table of NC turret punch moves to desired position [1, 2]. The above motion control system has the characteristic of good reliability, open and universality and can be explanted easily to all kinds of development of motion control system such as engraving machine, NC machine tool and so on. By using MFC of VS2015, the motion control system of NC turret punch press feeding mechanism is developed.

The Hardware of Motion Control System of Feeding Mechanism

Introduction of DMC1410 Motion Control Card

DMC1410 is a kind of pulse motion control card based on PCI bus which is made by Shenzhen Leadshine Technology Co., ltd. And the card can realize up to four stepper/servo motors control. The structure of DMC1410 is shown in fig.1. Its PCI bus is an advanced high-performance reusable local bus 32/64 bit address bus with plug and play hardware linear interpolation, S speed control curve and other functions. Its location instruction can output single channel pulse (pulse + direction) or dual pulse (CW pulse + CCW pulse) mode which is a differential or single type signal [3, 4]. DMC1410 motion control card has the characteristics of high integration, high reliability and so on.
The DMC1410 motion control card can finish continuous trajectory and point movement. The speed control and position control are realized by point movement. The position control mode contains two kinds of acceleration and deceleration mode: ladder curve acceleration and deceleration and S curve acceleration and deceleration.

The Structure and Principle of System Hardware

The sheet unstacking is the first process of automatic punching. When the sheet is transported from stock shop to sheet punching workshop, the sheet is separated with the sheet separation device of automatic feeding mechanism, then grabbed with the sheet grab device, and finally put to the designated position. The sheet feeding mechanism requires precise position and angle positioning in the process of sheet crawl, unstacking and placement. As high precision and speed are needed in the process of sheet metal grasping and placing, the traditional control system can not meet the higher requirements. The hardware of the motion control system consists of the following four parts: motion control card, PC, servo drive and servo motor as shown in fig. 2. The motion control card uses DMC1410 four axis motion control card. The model of servo drives is Kinco ED-430 and the model of small inertia three phase servo motor is +60S-0040-30XXX-4LG. PC and motion control card constitute the control unit. The PC mainly manages the information flow and data flow, controls the real-time system monitoring and human-computer interaction. The dedicated CPU on the motion control card and PC constitute a master-slave control structure. The movement control card control automatic lifting of feeding mechanism, output of the pulse and direction signals, detection of origin and limit signals and so on. The drivers are connected with the interface board of the motion control card, the speed is controlled by the encoder, and the pulse signal received from the motion control card controls the operation of motors through the internal circuit. So a half closed loop servo control system is constituted.

The Motion Mode of Trapezoidal Velocity Curve

Trapezoidal velocity curve is shown in fig. 3 which is used in general position control. In the process of this motion mode, the table accelerate in a constant acceleration, the start moving at constant speed when the speed achieves a specified value, and decelerates in a constant acceleration after running a certain distance. The trapezoidal velocity curve includes three stages: constant acceleration phase, uniform phase and constant deceleration stage.
The running speed changes with trapezoidal curve as the inertia of the table. It is impossible that the motor rotor or the table achieve the specified speed in an instant, therefore, there must be a certain acceleration process. During the acceleration and deceleration process of the trapezoidal curve, the speed turning and the corresponding acceleration mutation are shown in four moments: starting up, reaching the set speed, slowing from the maximum speed and stopping.

The main advantages of acceleration and deceleration according to the trapezoidal curve are that the target position and velocity can be automatically modified in the movement process, the control method and the calculation are simple suitable for real-time operation, and the acceleration and deceleration time is shorter. This method is applicable to the control system with slow processing speed and less requirement to acceleration and deceleration.

**The Motion Mode of S Velocity Curve**

The acceleration of S type velocity curve is a continuous change process as shown in fig. 4. As the acceleration or deceleration increases or decreases linearly, the mechanical motion stationarity of S type velocity curve is better.

![Figure 3. Trapezoidal velocity and acceleration curve.](image1)

![Figure 4. S velocity and acceleration curve.](image2)

The processes of acceleration and deceleration in this motion mode are symmetrical, and the whole running process is divided into seven stages: increasing acceleration phase, uniform acceleration phase, decreasing acceleration phase, uniform speed phase, increasing deceleration phase, uniform deceleration phase, decreasing deceleration phase. From the S velocity and acceleration curves, the conclusion can be drawn that the velocity and the acceleration are continuous functions of time t. This motion mode has small impact and small noise, and the service life of motor and mechanical system can be prolonged.

The position and velocity can be modified at any time during the running process with the trapezoidal curve, and the position can be modified with the S curve. In the case of equal acceleration, the acceleration and deceleration time is shorter with the trapezoidal curve and the movement is more smooth with S curve. So the acceleration and deceleration mode should be chosen according to the specific application.

**The Software of Motion Control System of Feeding Mechanism**

**The Modular Design of Motion Control System**

The overall structure of the software uses modular design which is easy to maintain and upgrade [5]. According to the idea of modular design, the software of motion control system of feeding mechanism is divided into the following modules as shown in Figure 5:

1. Initialization module, to initialize the motion control system of feeding mechanism including the initialization of interface, motion control card and other parameters.

2. Parameter setting module, to set the relevant velocity, acceleration, position of feeding mechanism.
(3) Motion control module, to realize the motion control of the whole feeding mechanism, including the selection of motion mode, receiving signal of limit and switch, returning to zero, sending motion command to motion control card and so on.

(4) Status display module, to display all kinds of real-time information including the display of movement status, velocity, acceleration, etc.

(5) System management module, including the management of files, NC programs, stamping dies, fault and alarm information, etc.

Figure 5. The module diagram of motion control system software.

According to the demand of the operating process of the Feeding Mechanism, the flow chart of the motion control system is designed as shown in fig. 6. When starting the system, the initialization is done and then to check if the initialization is correct. If it is error, display the error message and the initialize the board again, and if it is correct, continue to set the motion parameters including X, Y, Z axis motion control pulse output and the speed of the pulse. After finishing the parameter Settings, startup the motion, implement the control procedure, and status display module displays the motion status including speed, location and other information. Each functional module of the motion control system of feeding mechanism is coordinated and controlled by the main frame program constitute a complete coordinated motion control system.

Figure 6. System software flow chart.
Implementation

VS2015 is a powerful visual programming tool and one of the commonly used program development platform. DMC1410 provides related drivers and development functions. Under the support of MFC provided by VS2015 and movement function library provided by DMC1410 motion control card, the software of motion control system is developed.

As the motion control system uses modular approach, it is easy to maintain. And the motion control system has the characteristic of reconfigurability and scalability. The development process of the modular design is that the main structure and process of software are described such as main program, sub-program, sub-process and so on, the input, output, link and other relations among various frameworks are defined and debugged, and thus a series of algorithms describing the function blocks are obtained.

It is necessary to develop a convenient and friendly interface for the requirements of the motion control system. The main function of the interface is to display the various function information of the system in various ways, and transfer the user's input and selection into the corresponding data to the control system.

Users can develop the interface corresponding to the requirements of the control system, and call the corresponding functions provided by the motion control card to meet the development requirements of the motion control system. According to the design of the interface and the function of the motion control system, the interface can be achieved through the response function, such as in dialog box, there are three buttons of X, Y, Z axis, in order to set the corresponding speed, acceleration, distance and motion mode and selectively read the corresponding parameter, the implementation process is shown as follows:

If the independence movement of three axis is in a continuous motion mode, call response function of v_move (axis, str_vel max_vel, Tacc) in the library of the movement function. When the motion ends, call the function of v_stop (axis, Tdec) to stop the movement of each axis.

Conclusions

The motion control system of feeding mechanism is developed including hardware and software with DMC1410 motion control card. In order to easily maintain and upgrade the software, the idea of modular design is used in the overall structure of the software. The software is development using MFC provided by VS2015 and movement function library provided by DMC1410 motion control card. The motion control system of feeding mechanism has the characteristics of high speed and high precision and overcomes the defects of the complex peripheral circuit and slow calculation in the traditional digital motion control device. In addition, the system is universal and can be easily transplanted into the development of various motion control systems.

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References