Advances in Computer, Signals and Systems (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/acss.2024.080202
ISSN 2371-8838 Vol. 8 Num. 2

Design of Automatic Gluing Control System Based on BECKHOFF Controller

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Keywords: Automatic Gluing Control System, Pick-Up Manipulator, HMI

Abstract: With the rapid development of the field of intelligent manufacturing, the demand for industrial control systems is also growing. A variety of high-performance and high-precision controllers are used in the production of manufacturing industry. This paper takes the BECKHOFF controller as the control core and designs an automatic gluing control system. Based on the control requirements of the gluing system, the hardware design scheme and software design scheme of the system are determined. After rigorous practical testing and long-term operation verification, the control system shows excellent performance. It not only runs smoothly and responds quickly, but also has a simple structure and it is easy to maintain. At the same time, the control system has good scalability and adaptability. It can easily cope with the adjustment of production scale and process changes. The control system effectively improves the coating accuracy and production efficiency. It significantly reduces energy consumption and production cost.

1. Introduction

In today's highly automated industrial production environment, automatic gluing system has become indispensable production equipment for many industries, especially in the field of semiconductor manufacturing is widely used. It is a kind of high-tech equipment that combines mechanical, electrical, hydraulic, pneumatic and other technologies. Its working principle is mainly using the precision control system, accurate control of the amount of glue, glue speed and glue trajectory, so as to achieve high-precision gluing effect. The gluing system in this paper is developed and designed for the needs of intelligent touch screen.

Figure 1 is the structure schematic diagram of the automatic gluing system. This system consists of three main parts: pick-up manipulator, gluing platform and delivery manipulator. The role of the pickup manipulator is responsible for grabbing the touch screen that needs to be glued and transferring the touch screen to the automatic gluing platform. After the automatic gluing platform receives the touch screen, it firstly corrects the position of the touch screen through the image recognition technology. The gluing machine glues the touch screen after the position of the touch screen is adjusted accurately. And after the gluing is finished, the delivery manipulator comes to fetch the touch screen which has been glued and transmits the touch screen to the next working station. This is the workflow of the gluing system.

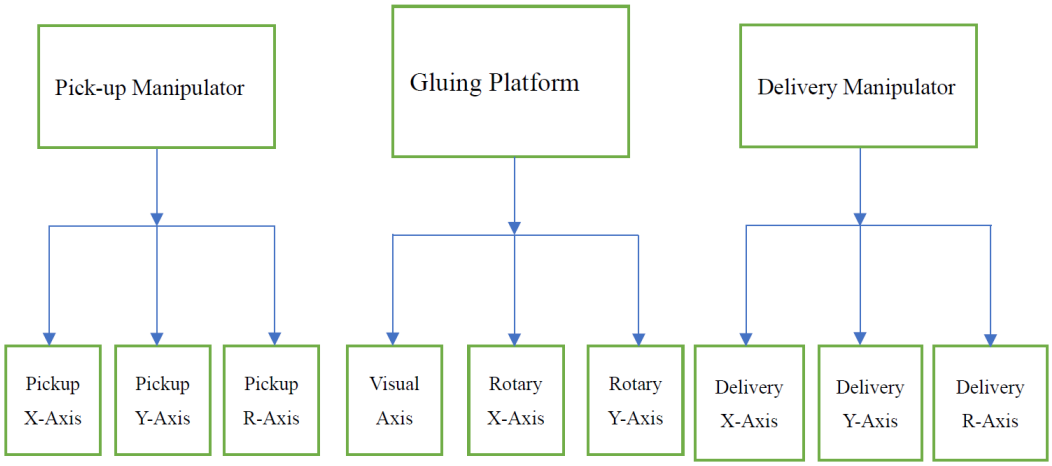

Figure 1: Structure of the automatic gluing system

2. Hardware Design of the Automatic Gluing System

The main components of the electronic control include motion controllers, motors and drives for motors, image processing terminals, cameras, optical systems, interface data computers, detection units, IO modules, sensors, and smart factory software interfaces. The electronic control system is designed with bus connection distributed control.

(1) Controller Selection

This device is a high-speed and high-precision device. General motion controllers cannot meet the needs of this equipment. After designing several control schemes and comparing the performance of various controllers, we finally choose BECKHOFF controller and use TwinCAT programming environment. The main controller chosen for this design is C6640-0030. TwinCAT is a PC-based motion control software from BECKHOFF, Germany. Because this controller applies EtherCat bus communication, so the controller has a short communication cycle time, flexible control, simple structure, easy to upgrade and transformation. TwinCAT software consists of TwinCAT NC and TwinCAT PLC. We can directly use TwinCAT NC software to control servo motors, solenoid valves and other electrical equipment, and in TwinCAT PLC you can write motion control programmes. By connecting the written programme to the TwinCAT NC-controlled electrical device, the programme can be used for automatic control [1-3].

(2) Selection of other hardware modules

The memory card module of the controller selects CX2550-0020, and the power supply module selects CX2100-0004. Because the controller is based on EtherCat bus communication, a bus connection module must be selected when applying the BECKHOFF controller. This time, EK1100 is chosen as the bus connection module. The EL1819 and EL1202 were selected as the input modules for this design. The EL1819 digital input terminals have 16 input channels, and the reference ground for all terminal contacts is a 0 V power contact. The EL1202 module is a high-speed and high-precision I/O terminal. It is based on the distributed clock synchronisation principle. The input terminals read the input data within a strictly defined time. The control system's output modules are EL2809, EL2819 and EL2202, of which EL2809 and EL2819 are 16-channel standard output terminals for single-wire connection, which send output signals via LEDs [4]. The maximum output current is 0.5A per channel and the rated voltage is 24 V. The difference between the two is that the switching time of the EL2819 is much smaller than that of the EL2809, and the EL2819 module has a self-diagnostic function that allows each channel to diagnose itself for overheating, short-circuiting, and power failure problems. In order to ensure the safety and stability

of the system, the EL2819 module is used in the design of the equipment. When there is overheating or short-circuit in the output channel, the BECKHOFF controller can quickly receive the alarm signal and give the corresponding treatment to ensure the normal operation of the equipment. The EL2202 is also a high speed and high precision I/O terminal module with a switching time of less than 1 US, which is ideal for the fast and precise control of solenoid valves when applying glue. In this design, EK1122 is selected for the connection branch module and EL9011 is selected for the end segment module [5]. As this control system is based on EtherCAT bus protocol, but some peripheral devices in the system are based on RS422 protocol, so this device needs to connect the peripheral RS422 interface device to the control layer, the EL6021 module is selected to connect it to the EtherCAT layer.

The whole control system consists of 9 servo motors, among which 3 servo motors are needed for the Pick-up Manipulator, which are the Pickup X-Axis motor responsible for horizontal movement, the Pickup Y-Axis motor responsible for forward and backward movement, and the Pickup R-Axis motor responsible for the rotation of the Pick-up Manipulator. The Delivery Manipulator also requires three servo motors, which are used for the same purpose as the three servo motors corresponding to the Pick-up Manipulator. The gluing platform has an image recognition system, which needs to be equipped with a vision Axis motor, the adjustment platform in the gluing platform requires two servo motors, a Rotary X-axis motor and a Rotary Y-axis motor. These nine servo motor models need to be selected by combining the design requirements of the mechanical system of the equipment and the control requirements of the electronic control system. This design also requires the selection of a photoelectric sensor as a limit, which is used to limit the maximum travel of the motor and prevent the motor from travelling beyond the maximum travel and crashing the mechanical system.

(3) Parameter configuration of the automatic gluing system

After completing the hardware wiring of the system, it is necessary to configure the parameters of the hardware. For the needs of the control system, first of all, the parameters of the servo drive and other electrical equipment for the initial configuration, its detailed parameter configuration needs to be configured in the debugging stage of the control system.

The TwinCAT NC software is the heart of the BECKHOFF controller, TwinCAT NC is a PC-based software motion control. The functions of the NC axes are divided into trajectory planning, PID operations and IO interface handling. The Configuration of TwinCAT NC axes including: encoder, drive, NC controller and the interface of PLC. We use TwinCAT NC software to scan the hardware, and once the scanning is complete, we can see all the servo drives and IOs of the control system that we need to be connected to the BECKHOFF controller in TwinCAT NC [6]. The next step is to set the parameters of the servo motor in the TwinCAT NC software, such as speed, target position and so on. Once the parameters have been set, a preliminary commissioning of all the electrical equipment scanned in is carried out.

3. The Software Design of Motion Control System

The core of the control system design is programming, which requires logical control according to the control requirements of the equipment. The modular design idea is followed in the design, so that the programme has good modularity, modifiability and portability. Firstly you need to define the variables required for the programme in the TwinCAT PLC, including information such as variable addresses and variable types. The design can choose the ladder language or ST language to write the program, combined with the specific situation of the control scheme, the control system uses the ladder language and ST language mixed use. The programme includes a debugging programme and an automatic programme. The debugging programme is used when the equipment

is being debugged. The automatic programme is used to control the equipment to achieve the normal operation of the equipment. The main programme of the equipment is written according to the control requirements. Firstly, after receiving the feeding signal, the Pick-up manipulator starts the Pickup X-axis motor to move to the position calibrated at the commissioning stage, and then starts the Pickup R-axis motor to rotary to the target angle. After that, we start the Pickup Y-axis motor to move to the calibrated position. After the end of the picking, we control the three motors of the Pick-up manipulator to make the Pick-up manipulator move to the loading station and put the touch screen on the gluing platform. The BECKHOFF controller then sends a start signal to the visual axis motor, which moves the vision system to the calibrated position for image processing. The vision system calculates the difference between the current position of the touch screen and the actual calibrated position and then passes the calculated difference to the BECKHOFF controller. The controller receives this difference and controls the rotary X-axis motor and the rotary Y-axis motor to move the corresponding distances so that the controller adjusts the touch screen to the exact paint position. Since the visual axis motor moves both the glue applicator and the vision system, when the above steps are finished, the visual axis motor starts to move the glue applicator according to the calibrated trajectory. At the same time, the BECKHOFF controller controls the applicator to apply glue to the touch screen. After the gluing process is finished, the BECKHOFF controller controls the Delivery X-axis motor, the Delivery Y-axis motor and the Delivery R-axis motor of the Delivery manipulator to move the Delivery manipulator to the calibrated picking position. Then the Delivery manipulator removes the touch screen from the gluing platform and puts it to the next station. Since the program is written according to the modularisation idea, it is necessary to write the program in blocks and define the interfaces between the blocks. When writing the programme, I define the parts with the same function as function blocks. The main programme calls the function blocks directly when it runs. I write the working process of the Pick-up manipulator, the working process of the Delivery manipulator, the image recognition process and the gluing process as FB modules for the main programme to call directly. To ensure the integrity of the programme, the programme should also include an alarm programme, a reset programme, a stop programme, a zero search programme, a protection function programme and so on.

4. Design of the HMI

TwinCAT PLC not only allows you to write PLC programmes, but also integrates the configuration development tool TwinCAT HMI. In this design, I designed the HMI of the automatic gluing system, which can be applied by the user for real-time monitoring and management of the equipment. The HMI is able to display the working status of the equipment and the abnormal condition of the equipment. At the same time, it can also record the operating data of the equipment. Once the equipment malfunction, the HMI will display an alarm signal [7-9]. So that the user can be based on the display of the alarm signal to make the appropriate treatment. In order to ensure the normal operation of automatic gluing equipment, the man-machine interface combines the control requirements. It has a good interactive interface and stable operation, as well as the characteristics of scalability. Figure 2 shows part of the HMI control interface for this design. The right side of the HMI contains the control system's overall start button, reset button, stop button and the device's zero search buttons. When the user presses the ENABLE button, all motors are in the enable state. When the START button is clicked, the whole device starts to work normally. When the RESET button is clicked, the device starts to reset. When the STOP button is clicked, the device stops working. When the device is first started, the device has to perform an overall zero search, this time you need to click the HOME button. The left side of the HMI contains all the operating status of the

pick-up manipulator, delivery manipulator and gluing platform of the machine. The HMI is capable of displaying the real-time position of all motors and controlling point-to-point and JOG motions of motors. It also contains buttons for controlling motors to perform various movements required by the control system. It also has buttons for clearing alarms and controlling solenoid valves and so on.

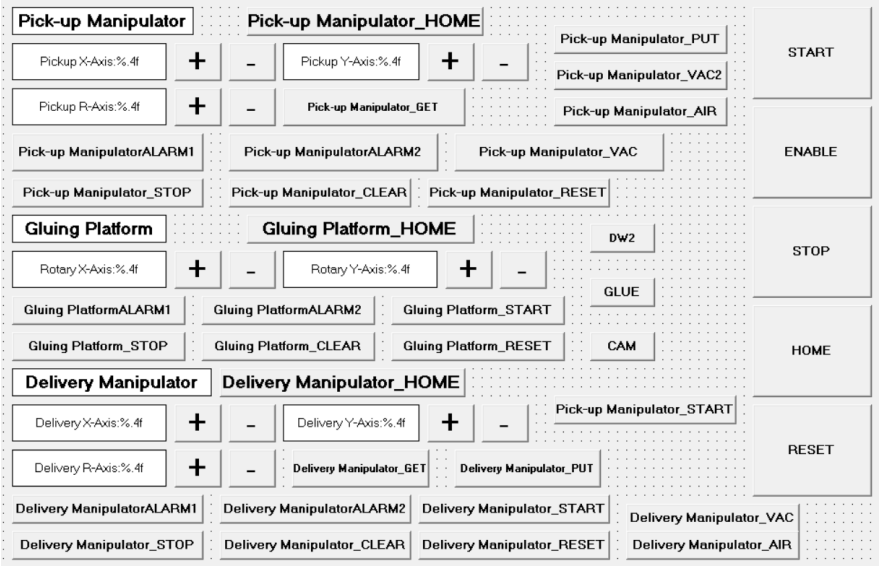

Figure 2: HMI of the automated gluing system

5. Conclusion

In this paper, an automatic gluing control system based on BECKHOFF controller is designed. This control system has simple hardware structure, good hardware scalability, stable software operation and high degree of intelligence of the equipment. If a fault occurs during operation, it can be alarmed in time and handled automatically. It is also capable of displaying and recording various production conditions of the equipment in real time. The machine is highly productive and it combines safety and stability.

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