The Control System Design of Aircraft Wheel Device of Driving Rotary

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Abstract. The aircraft wheel device of driving rotary is an important device as test of anti-slip brake system on the ground, according to the problems of inconvenience of input parameters adjustment, low speed detection accuracy, poor adaptability to the outside environment and low degree of automation, this paper designs a set of controlling system of aircraft wheel device of driving rotary, and giving chart with hardware design and programming flow chart in the control system of aircraft wheel device of driving rotary. The application result shows that this control system can meet actual requirement in the test of anti-slip brake system.

1. Introduction
The structure of the wheel belt turning device is shown in Figure 1. The wheel belt turning device is mainly composed of a trailer, friction wheels, a motor, a belt, a protective cover, and an electrical cabinet. By controlling the friction wheel to drive the wheel to rotate, it is used to check the normal operation and working reliability of the wheel anti-skid brake system on the ground, and then to meet the technical requirements of the aircraft ground test and inspection, and to ensure the safety and reliability of the aircraft’s take-off and landing.

![Figure 1 The structure diagram of the wheel belt rotating device](image)

The trailer is assembled from a number of parts, including the frame chassis, casters, handles and so on, which constitute the overall support of the wheel belt turning device. The chassis of the frame is welded by a steel structure. Casters are installed on the lower part of the chassis. The casters are equipped with a brake device. They are used to brake the wheel and turn device during operation. It has the characteristics of good stability and convenient movement. A rigid handle is installed on one side of the chassis of the frame, and a rubber protective cover is provided on the handle, which not
only plays a role in insulation, but also avoids contact between the hands and the rigid handle at low temperatures. The friction wheel is made of vulcanized rubber material, which is convenient for good contact with the wheel. The arc surface of the friction wheel is designed according to the radius of the arc surface of the wheel, so that the friction between the friction wheel and the wheel meets the requirements of use. The motor is used to drive the friction wheel and drive the friction wheel to rotate. The motor base and the frame chassis are connected by bolts and become a whole with the frame chassis. The motor and the friction wheel mechanism transmit power through the belt, and a protective cover is installed outside the belt to ensure the safety of the operator. The motor is equipped with a protective cover to protect the motor from rain and dust. At the same time, install an electrical control cabinet on the trailer, install the electrical components inside the electrical control cabinet, and effectively control the wheel belt turning device through the electrical control cabinet[1-3].

2. Working principle of wheel belt rotating device

The principle block diagram of the wheel belt device is shown in Figure 2. The system is divided into two parts: control and detection. The control part controls the frequency converter through the PLC controller system and drives the motor. The motor drives the friction wheel to rotate, and the friction wheels drive the wheel to rotate. The inverter is controlled by the PLC controller system, and the frequency of the inverter is changed in real time to achieve the speed control of the motor, realize the speed adjustment of the wheel, and meet the speed adjustment control requirements of the wheel.

The detection part is to detect the speed of the friction wheel and the wheel. The speed detection of the friction wheel adopts the photoelectric rotary encoder method. The photoelectric rotary encoder is connected to the friction wheel through a mechanical installation method. The rotation of the friction wheel drives the photoelectric rotary encoder to rotate. A series of pulses are output during rotation to realize the speed detection of the friction wheel. The speed of the wheel is detected by attaching a reflective tape to the wheel, and the photoelectric sensor is used to complete the detection. The photoelectric sensor signal is connected to the PLC controller system to control the start and stop of the encoder pulse counting, and when the photoelectric sensor detects the reflective belt, it will start counting, and it will stop counting when the reflective belt is detected again. At this time, the wheel rotates exactly once, the number of revolutions can be calculated by counting the number of pulses, and combine with the diameter of the wheel and other parameter information, finally the actual speed of the wheel can be calculated, and the data will be displayed through the touch screen, the process all above are the entirely speed measurement and display.

![Figure 2 Block diagram of working principle](image-url)

3. System hardware design

The hardware of the control system of the wheel belt turning device follows the design principles of safety, stability and reliability to ensure that the system is easy to maintain and operability[4]. The system uses PLC controller as the core processing unit, and combines touch screen, frequency converter, temperature control meter, solid state relay, temperature sensor, rotary encoder, control
button, status indicator, etc. to form a set of detection and control system. It can realize the speed control, speed detection of the wheel and belt rotation, and the temperature sensing detection and control function. The hardware structure of the control system is shown in Figure 3.

As the core processing unit, on the one hand, the PLC controller collects on-site input information for analysis and processing, and on the other hand, it controls the on-site execution devices, equipped with Ethernet, RS485 interface and RS232 interface. It communicates with the touch screen through the Ethernet interface, it exchanges data from two aspects: the inverter through the RS485 interface, the temperature control meter through the RS232 interface, and a high-speed pulse input interface is also equipped, which facilitates the connection with the rotary encoder, and expands multiple input and output. In summary, we can meet the requirements of the system's collection and control points and the PLC controller is selected as Siemens SMART 200 series.

The PLC controller collects the signals of the control buttons, mainly including: heating start and stop, motor start and stop, motor forward and reverse rotation, fault emergency stop, etc.; the collection of induction signals, mainly including: the signal output by the rotary encoder and the signal output by the photoelectric sensor. Among them, the rotary encoder is used to collect the real-time speed of the friction wheel, connect with the friction wheel by a coupling, and transmit the data to the PLC controller for data processing. The photoelectric sensor is used to measure the rotation speed of the wheel, and is used in conjunction with the reflective tape to measure the rotation speed of the wheel in real time, and transmit the data to the PLC controller for data processing. The PLC controller can control the temperature control meter, including the control of the temperature control meter and its heating start and heating stop. Besides, the PLC controller can also control inverter, mainly including motor high, medium and low speed operation, motor forward rotation, motor reverse rotation, etc. The control operation status indication includes: motor operation, heating system operation, device operation, etc.; fault status indication includes: motor thermal protection, Inverter failure, temperature control meter failure, etc., and the power indication, indicator light output and sound and light alarm of failure are also equipped.

As a more convenient way of human-computer interaction, touch screens have been widely used. The user can send start/stop motor commands, forward rotation commands, reverse rotation commands, speed parameter settings to control through the touch screen, and the interface can also display speed, temperature parameter settings and their status. With Ethernet communication interface, it is convenient for bus connection and data interaction with PLC controller. The touch screen uses DC 24V for power supply. When the friction wheel speed setting range is 450r/min-500r/min, the operation panel can display the current wheel speed in real time. When in use, the user can adjust the speed by setting the size and direction of the rotation speed on the operation panel, and the response

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**Figure 3** Block diagram of the hardware system structure
speed of the speed control device should meet the needs of use. Considering the factors all above, the Kunlun Tongtai TPC 10-inch screen is selected.

As an electrical device for driving the motor, the frequency converter changes the input frequency of the frequency converter in real time to realize the speed control of the driving motor through the touch screen, and finally to realize the speed control of the wheel. Including a variety of speed adjustment methods, the frequency converter and PLC controller are connected through the RS485 interface for data interaction, which is divided into multiple speed adjustments such as X1, X5, and X10. The motor used in the system is 7.5KW, and the inverter uses Delta VFD075B43B series.

In order to improve the demand for the outside use of wheel and belt rotating equipment, an automatic temperature adjustment system is designed. The system combines temperature control meters, solid state relays, heaters, temperature sensors, etc. to achieve real-time collection of external temperature signals by using temperature sensors, and it is sent to the temperature control table, and the temperature is set and compared through the temperature control table to start the effective control of the heater by the solid state relay, and then to realize the automatic adjustment of the temperature, and ensure the stable operation of the control system. The heater adopts three 1KW heating resistors, the temperature control meter adopts conductive SR90 series, and is equipped with an RS232 interface. The real-time temperature collected and controlled by the temperature control system is transmitted to the PLC controller and displayed on the touch screen.

At the same time, the device provides corresponding protection functions, using air switches, circuit breakers, fuses and other devices, as well as hardware monitoring of the inverter's fault information, to achieve system overload and short-circuit protection functions to ensure the safety of the control device.

4. software design

The control system software adopts a modular structure design, and the system software includes two parts: PLC program and man-machine interface. The PLC program is developed using Siemens STEP7 Micro/WIN SMART standard tool programming software[5], which can complete data acquisition, motor start and stop, motor operating parameter calculation processing, temperature parameter calculation processing, test data analysis processing, fault alarm and other functions, to meet the requirements for the test of wheel anti-skid brake system.

The software development process is shown in Figure 4. The PLC program mainly includes data acquisition module, parameter setting program, filter program, manual control program, automatic control program, temperature control program, data analysis storage module and alarm management module.

The man-machine interface is mainly used to set system operating parameters and display real-time operating status. The interface includes the main display information screen, parameter setting screen, operation screen, data query screen, fault information screen, and composition. The content displayed on the main display information screen includes motor status, temperature detection value, input switch value, and system prompt information. The parameter setting screen includes the temperature to be heated, the temperature time parameter for heating, the high, medium, and low running speed of the motor, and the motor acceleration and other parameters. The operation screen includes automatic operation, manual operation, maintenance operation, etc., to realize system maintenance automatic, manual, maintenance and other operation functions. The data query screen includes heating temperature curve, wheel running speed curve, motor running curve and other information. The fault information screen is used to prompt user equipment fault information and possible causes, such as motor overload alarm, temperature over-temperature alarm, inverter fault, and PLC fault information.

The system is powered on, the initialization program is called, and the initial value is assigned to the corresponding variable, so as to realize the initialization of the corresponding module, and the system enters the ready state. Set the corresponding motor running data parameters and heating temperature parameters on the touch screen. On one the hand, we can start the program to execute the first start-up motor execution program, detect the current wheel running speed, and judge whether the
wheel running speed meets the requirements. When the speed is met, we can start the normal test, start the motor again, monitor the wheel speed, analysis and process the collected data, check whether the test data is qualified, stop the motor operation after it is qualified, and store the current data of each test. The process is convenient for tester to query. On the other hand, during the beginning of the test process, the temperature is set through the touch screen as required, and the system will compare the set temperature with the current temperature, and perform system heating control to meet the requirements of the field test. At the same time, due to the high frequency interference of the inverter in the control system, it will cause the jitter of the data collection of the rotary encoder and the photoelectric sensor, which will affect the collection of the rotary encoder and the photoelectric sensor and ultimately affect the accuracy of the system. In order to ensure the reliability of the system, the system software processing adopts digital filtering method to eliminate or weaken the influence of interference and noise. The encoder outputs a square wave pulse signal without interference or vibration, and the signal frequency is low, but when vibration exists, the additional pulse frequency generated in this way is generally higher, and the high frequency is filtered out by digital filtering. Vibration signal makes the system operation safer and more reliable.

![Software development flow chart](image)

5. Conclusion
The system comprehensively uses human-computer interaction, PLC control, frequency conversion control, temperature control, and communication technologies to design and develop a wheel belt turning device control system. The friction wheel is driven by the motor to rotate, and then the friction wheel is driven to rotate the wheel, and then it realizes the transmission of the wheel. At the same time, the system can perform a variety of speed adjustment controls on the wheels, real-time online detection of the speed of the wheels and friction wheels, and automatic temperature control. It has the characteristics of stability and reliability, simple operation and suitable for field use, which satisfies the aircraft ground test. The technical requirements of the inspection have improved the automation level of the wheel belt turning device, further improved the test efficiency of the wheel anti-skid brake system, and ensured the flight safety of the aircraft.
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