Development of remote data acquisition system based on OPC for brake test bench

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Abstract. The 1:1 train brake system test bench can be used to carry out brake-related adhesion-slip control, stability test, noise test and dynamic test. To collect data of the test bench, a data acquisition method is needed. In this paper, the remote data acquisition system of test bench is built by LabVIEW based on OPC technology. Unlike the traditional hardwire way connecting PLC acquisition module with sensors, the novel method is used to collect data and share them through the internal LAN built by Ethernet switches, which avoids the complex wiring interference in an easy, efficient and flexible way. The system has been successfully applied to the data acquisition activities of the comprehensive brake system test bench of CRRC Nanjing Puzhen Haitai Brake Equipment Co., Ltd., and the relationship test between the adhesion coefficient and the slip-ratio is realized. The speed signal, torque signal and brake disc temperature can be collected and displayed. The results show that the system is reliable, convenient, and efficient, and can meet the requirements of data acquisition.

1. Introduction

At present, the methods of studying the characteristics of train wheel and rail adhesion mainly consist of two kinds, namely, theoretical research and experimental research. However, the theoretical study is constrained by the real wheel rail contact conditions. In order to make up for the lack of theoretical research, CRRC Nanjing Puzhen Haitai Brake Equipment Co., Ltd. set up a comprehensive test platform for the braking system. The railway vehicle was used as the experimental object to simulate the contact condition of the rail wheel and vehicle wheel. In the course of the experiment, many physical parameters of the test bench need to be collected, processed and displayed for operator reference. Therefore an effective data acquisition system is necessary for the experiment.

With the development of computer communication and control technology, data acquisition system in the industrial field has attained mature development. OPC (Object Linking and Embedding (OLE) for Process Control) provides a software interface standard for data source and data user communications, which establishes a communication bridge for process control data sources and Windows-based applications.

This paper is based on the LabVIEW platform for software design and the OPC protocol for data transmission. The software with good human-computer interaction interface was developed to achieve real-time communications. The physical parameters were shared by Ethernet, reducing the hard wire
transmission wiring complexity and low stability, to realize a multi-point, real-time, efficient remote data collection. As the OPC structure is the client / server model, each OPC client connects to the OPC server management device through the OPC standard interface, so the system needed to establish the OPC interface, connections between the OPC server and OPC client applications, as shown in Figure 1.

![Figure 1. OPC clients and OPC servers](image)

2. System Architecture and Design

2.1. System Architecture

The data acquisition system of brake test bench is composed of sensors, data acquisition card, serial interfaces, other hardwares and host computer configuration software. Among them, the hardware part of the data collection consists of computers, high-speed acquisition modules and signal isolation modules, which make the full use of high-speed, high-capacity storage and powerful computing analysis functions of computers and increase efficiency. During the experiment, the rail wheel speed signal, the torque signal, the brake disc temperature, the brake cylinder pressure and other signals are collected. The collected data are uploaded to the detection computer at the same time for data analysis, calculation and display. The control computer can save the test data automatically according to the requirement.

2.2. Scheme Design

The data flow of the collection way is displayed in Figure 2. In the figure, the force sensors, displacement sensors, signal conditioning modules and the acquisition cards transfer the acceleration, pressure and other physical parameters through the EPM shielded cable in the form of 4-20mA current signal; The camera and the temperature sensors collect the related data and transfer them to the high-speed data acquisition card through the RS485 serial interfaces; PCI high-speed data acquisition cards communicate with control computer by switch in the Ethernet.

![Figure 2. Flow chart of data acquisition](image)

In order to solve the data transmission between the host computer and the lower computer, this paper uses NI Data Socket function to realize the data communication between LabVIEW and OPC Server. Data Socket is a network communication technology for the field of measurement and control. Using it can provide a platform-independent solution transferring data over the network, solve the problem of data acquisition, processing and display of remote instruments and equipment at the speed of 640kbps in 10M networks, which can achieve a very good transmission effect and avoid the failure of hardware facility.
3. System Hardware Components

3.1. Sensors
The data acquisition system needs to detect the physical variables and convert them into usable signals, thus requires a large number of sensors to meet the requirements of information transmission, processing, storage, display and control. The usage and selection of sensors are the primary part of the data acquisition system.

The system needs to collect signals such as speed, torque, pressure, temperature, etc., the key physical variables and the sensors used are shown in Table 1. The rotational torque measuring position is located between the motor end and the rail wheel, between the rail wheel and the gear box and between the brake discs and the flywheels group. Temperature detection uses infrared temperature detectors, which are non-contact sensors.

| Key parameters                | Sensors          | Range            |
|-------------------------------|------------------|------------------|
| Wheel speed [km/h]            | Speed sensor     | 3000r/min        |
| Rail Wheel speed [km/h]       | Speed sensor     | 3000r/min        |
| Torque meter torque [kN*m]    | Torque meter     | 20 kN*m          |
| Brake Cylinder Pressure[kPa]  | Pressure sensor  | 1MPa             |
| Brake disc temperature [°C]   | Infrared temperature sensor | -40-1030°C |

3.2. High-Speed Data Acquisition Module
The lower computer uses PCI6225 data acquisition card using the PCI bus (Peripheral Component Interconnect). It can be directly inserted in any compatible computer within any PCI slot. The NI PCI-6225 data acquisition card is a low-cost multi-function M-series data acquisition card with 16-bit, 80-channel analog and 24 Road digital, which is optimized for applications requiring cost control. In order to use the NI PCI-6255 for optimum performance, the system uses an EPM shielded cable 50CC01 for connector connection, as recommended by NI. The lower computer collects the real-time data from the PCI high-speed acquisition card through the DAQ assistant in LabVIEW, setting the sampling number, channel and other parameters, and then connects with the host computer through Ethernet.

3.3. Serial Interface
Serial interface transmits the data one by one. It is characterized by a simple communication line, which achieves two-way communication.

The system uses RS-485 bus interface, it is a balanced transmitting and differential receiving serial bus. The transmission speed, distance, anti-common mode interference capacity are suitable for the test bench. The support for serial communication of LabVIEW is realized by VISA (virtual instrument software architecture), the functions include: VISA configuration serial interface, VISA write, VISA read and VISA off. The key is to read the buffer and convert the data format, in order to access the data in LabVIEW, which is shown in Figure 3.
4. System Software Design

4.1. Data Acquisition

NI OPC Sever provides many manufacturer drivers, the Data Socket function in LabVIEW also uses OPC server for communication. Data Socket can effectively support different applications on local computers and exchange data between multiple applications on different computers in the same LAN, to achieve data exchange across process, across computers.

The specific software design method is: to define transmission protocol DSTP for the transmission of data across the network, the transmission protocol is in the form of URL type, which is similar to http, ftp.

The system collects the card corresponding to the URL dstp: //192.168.0.121/wavecard (responsible for acceleration, pressure) and dstp: //192.168.0.121/wendu (responsible for the temperature and other physical variables). LabVIEW obtains data items named "wavecard" and "wendu" from the OPC server via the above URL. Then the Data Socket function is used for the software, including open Data Socket, read Data Socket and close Data Socket.
It is noteworthy that the collected data by the acquisition card of the system are saved as the global variables during the software design process. That is because the global variables can be accessed anywhere in the brake test bench data acquisition system, and the addresses of global variables are fixed, thus improving the read and write efficiency. However, the disadvantage is the occupied memory of global variables affecting the memory property. Considering the number of global variables is small, this memory problem can be avoided.

Figure 5 shows the remote data access programmatic implementation (the lower machine IP address is 192.168.0.121); Figure 7 is the software front panel of test bench data acquisition system. As the physical variables can be grouped in accordance with the wheel number, the tab navigation bar with 6 associated views can be set in the front panel to display different corresponding parameters, namely the rail wheel (including two tab bars), flywheel (including two tab bars), brake performance, temperature. Operators can not only check the corresponding physical variables in the form of real-time data, historic data, waveform but also take values based on the result and enlarge or shrink the waveforms.

4.2. Data Operation
In order to obtain the relationship between wheel rail adhesion coefficient and slip rate, the data acquisition system needs to calculate the relevant data. According to the calculation method of wheel rail adhesion coefficient of railway vehicles, the braking adhesion coefficient is defined as the ratio of maximum braking force to axial load. The slip rate can be calculated according to the formula
\[ \zeta = \frac{v - \omega \cdot r}{v} \], where \( v \) is the vehicle speed, \( \omega \) is the wheel speed, \( r \) is the wheel rolling radius, shown in Figure 6, the sub VI calculates the adhesion coefficient and the slip rate.

![Data operation program diagram](image)

**Figure 6. Data operation program diagram**

### 5. Acquisition System Test

To verify the performance of the data acquisition system, the SWTB-400 bogie was selected as the test bogie, the vertical load using the adjusting weight up to 9 ton, and a number of adhesive tests were operated. During the test process, the traction motor was controlled by direct torque control method using frequency converter to maintain a constant speed, the brake cylinder pressure rises simultaneously, so that the wheels were decelerated and the velocity differences between vehicle wheels and rail wheels were made to simulate the "roll and slip" state of motion. At the same time, the system calculated adhesion, slip rate, vertical load and other physical variables.

Taking the test data as an example, the measurement and control performance of the test bench data acquisition system is shown in Figure 7, where the left ordinate is the brake cylinder pressure [kPa], and the right ordinate is the velocity [km / h]. As can be seen from the curve, the initial speed is 300km / h, the brake cylinder pressure remains stable at the range of 230kPa to 300kPa in the braking process. The relationship between the adhesion coefficient and the slip ratio calculated by the data operation module is shown in Figure 8, it can be seen that the adhesion coefficient is maintained between 0 and 0.3 throughout the test. During the test, the data acquisition system has strong anti-interference ability and high synchronization performance; there is no crash or stagnation phenomenon. The different physical variables can be displayed in real time. From the braking process it can be concluded that the system for the related data testing and acquisition is stable and reliable.
6. Conclusion
In this paper, the data acquisition system of the brake test bench was designed, which realized the functions of remote data acquisition, multi-point monitoring, LAN sharing and so on, using LabVIEW as development platform. It provides ideas for remote data acquisition. Tests show that the data acquisition system based on OPC technology is feasible. It realized real-time field data acquisition, operation and data exchange on different platform, reducing the cost and improving the efficiency of the test. It has been proved that the system has the characteristics of friendly man-machine interaction and high efficiency of data communication. The system also provides convenience for industrial production and provides solutions for professional research.

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