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Application of Internet of Things in Safety Management of Chemical Equipment

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In order to promote the development of factory information collection technology, this paper studies the application of Internet of Things (IoT) in chemical equipment information collection. Based on IoT, combined with factory quality management information collection methods, this paper attempts to integrate the factory and the Internet, and proposes an information collection system for chemical equipment information collection based on IoT. The research found that the accuracy of the wired collection module is 100%; there is basically no loss of wireless communication within 15m indoors, which meets the communication requirements of the general workshop. It can be seen that the system integrates a variety of inspection devices to realize automatic extraction, collection and storage of chemical equipment inspection information, which can provide high quality management for chemical plant management.

1. Introduction

In the era of network informatization, domestic chemical plants are gradually developing in the direction of intelligence and automation, and it is very important to realize the digitization and intelligence of chemical equipment information collection. SCADA (Supervisory Control and Data Acquisition) fieldbus-based control system is based on contemporary advanced network technology, enabling seamless data connection between chemical production equipment management and process control. The intelligence of chemical equipment information collection requires the use of digital chemical equipment information collection system. The chemical equipment information collection controls the plant's parts information and data through it, it plays an active role in the chemical plant's information management and production control, and realizes the collection and exchange of quality management information of the chemical plant.
It can be seen that we must actively research and develop equipment information collection systems, combining with advanced IoT technologies to enhance the intelligence technology of our factories, and promote the chemical industry to actively transform and upgrade. Based on IoT, this paper combines with factory quality management information collection methods, and attempts to integrate the factory and the Internet. It also proposes an information collection system for chemical equipment information collection based on IoT.

2. Literature review

Ling established a functional model of Integrated Quality System (IQS), developed a quality information system that supports design, manufacturing, and quality assurance of comprehensive quality management activities, and managed and statistically analyzed quality data through a relational database (RDB) (Ling, 2014). Wei et al. proposed the system framework of the quality information system of discrete mechanical manufacturing industry, and comprehensively studied the process specification based on database and the control chart use selection based on knowledge base and the assembly specification for quality control (Wei et al., 2014). Zhang et al. proposed a network-assisted manufacturing system model based on agile manufacturing. It includes a central network server integrated with CAD/CAPP/CAM/CAA to manage various data information in quality control and to allow local users to connect to the central server through the network interface (Zhang et al., 2014). Zhou et al. proposed a new distributed quality control framework to achieve

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rapid product design, process design and quality assurance, and customers could directly participate in product design and quality decisions of manufacturing process through the distributed network (Zhou et al., 2014). Wu et al. designed a quality control system for component assembly products in distributed manufacturing shops (DMS) based on clustering algorithms, collected quality data and stored it in a central database, and developed a prototype of the intelligent Web quality control information system (IWIS-QC) (Wu et al., 2015). Vassilis and Themis designed and developed a knowledge-based statistical quality control consulting system. The system can select and design appropriate quality control charts, generate process monitoring analysis reports, and provide effective solutions based on the analysis results (Vassilis and Themis, 2015).

Wilk studied the design and implementation of embedded Statistical Process Control (SPC) system for complex network environment based on the implementation model of statistical process control in multi-variety and small-batch manufacturing environment (Wilk, 2016). Sicari et al. proposed and studied the dynamic quality management system of workshop manufacturing process based on Manufacturing Execution System (MES) and realized the dynamic execution of the four stages of quality planning, implementation, inspection and treatment (Sicari et al., 2016). Li proposed an intelligent process quality control model integrating quality prevention, analysis, diagnosis and adjustment, and realized intelligent determination and adjustment of process quality with neural network and expert system (Li, 2014). Aiming at the characteristics of manufacturing site information acquisition and transmission, Xu and Li adopted two-level tree model wireless sensor network based on ZigBee standard to achieve real-time and accurate acquisition and transmission of manufacturing site information and developed simple and practical protocol stack software (Xu and Li, 2014). As a mature field bus technology, Controller Area Network (CAN) bus is widely used in industrial control and other fields to realize the interconnection between wireless Network and industrial bus. On the basis of analysis of CAN bus and Zig Bee technology protocol, Gao proposed a feasible scheme to realize the interconnection between CAN network and Zig Bee wireless network and explained in detail the method of protocol transformation of gateway (Gao et al., 2014). Xia modified steel continuous casting equipment by installing sensors and information transmission technology based on Zig Bee and Code Division Multiple Access (CDMA) to realize automatic, real-time, accurate and wireless access to the status information of steel continuous casting equipment, which provides key data for preventive maintenance and quality fault prediction of steel continuous casting equipment production line (Xia, 2015). Xiao et al. aimed at improving the production efficiency of coal mine underground mining, and urgently needed to improve the control status of production equipment. Combined with the requirements of relevant national regulations and the current equipment status of coal mines, the research on the design of integrated automation control system for coal mine production process was carried out. Establish a real-time production control monitoring network that meets modern production requirements and covers all mines in coal mines, realizes the automation of integrated production process monitoring of coal production and mining, and then designs a comprehensive coal mine automation control system that integrates coal mine production management systems and production processes to improve production. Facility equipment utilization. (Chen, 2018; Dutta et al., 2018; Xiao et al., 2018; Yan and Sun, 2018). To sum up, the above research work mainly focuses on the in-depth research on the quality control model and quality information management system of the processing workshop based on the digitalization of the Internet of things, but there are few researches on the quality management information acquisition of chemical equipment. In the era of network informatization, domestic chemical plants are developing towards intellectualization and automatization, and it is very important to realize digitization and intellectualization of information acquisition of chemical equipment. The intellectualization of information acquisition of chemical equipment needs the help of digital information acquisition system of chemical equipment. Therefore, based on the Internet of Things and the relationship between the acquisition methods of factory quality management information, the information acquisition system of chemical equipment based on Internet of Things is proposed, and the application of Internet of Things in the information acquisition of chemical equipment is studied.

3. Principles and methods

Table 1: Testing equipment

Inspection station	Station1	Station2	Station3	Station4
Detection Tool	CMM	Caliper 2#1 Inner diameter micro meter 2#1 Outside diameter micro meter 2#1	Depth gauge 3#1 Caliper 3#1 Outside diameter micro meter 3#1	Caliper 4#1 Caliper 4#1 Height ruler 4#3

There is one inspection station at each station in the actual production workshop, and each inspection station is equipped with a certain number of inspection devices (as shown in Table 1).
The manufacturers of these devices are mainly Mahr and Mitutoyo. Therefore, the information collection hardware system can be constructed according to the actual situation of the workshop. The hardware composition of the information collection system is shown in Figure 1, which mainly includes a data collection terminal server and a data conversion interface module. Among them, various digital inspection devices in the quality inspection system are connected to the terminal server through the data conversion interface, IoT networking is realized through data collection terminal server so that the communication protocol is unified and uploaded to the host computer through the network. The host computer uploads data to the enterprise database via local area network of the factory, and the digital management of inspection information exchanges information with the MES and ERP systems of the enterprise.

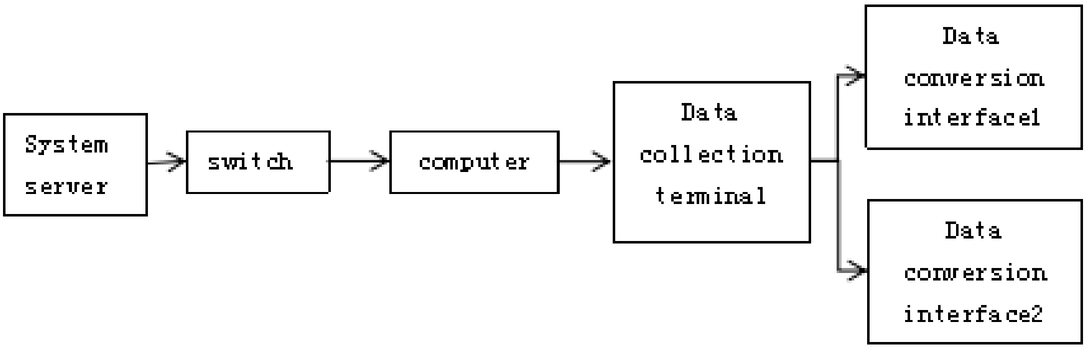

Figure 1: Information collection system hardware

The data collection terminal server is responsible for the data conversion interface and network information conversion. It is one of the core hardware devices in the parts quality management information collection system in the IoT-based digital factory. The principle of the data collection terminal server is shown in Figure 2. The main part consists of a serial server and a router. Among them, the main function of the serial port server is to convert the serial port data into network signal, and the router connects the network signal to the local area network of the factory, thus realizing the connection between the measured data and the network. In order to complete the task of serial port data and network information conversion, the serial port server is designed as a serial port-network conversion device. This server supports multiple modes of communication, including TCP server mode, TCP client mode, UDP mode, couplet mode, reverse terminal mode, and other working modes, which allow user software to access serial port devices through standard web application interfaces (winsock BSD sockets). The built data collection terminal server has 8 serial ports, which can support 8 different inspection devices to be connected at the same time, and has the out-of-tolerance alarm function. In the actual measurement, when the red indicator light is on, the inspected object is in the state of over tolerance. If the current measured data of the current tolerance is to be retained, press green button to skip automatically, then the system will turn to the next inspection element and perform measurement. If retesting is required, after pressing the green button, manual reselection is required for test again.

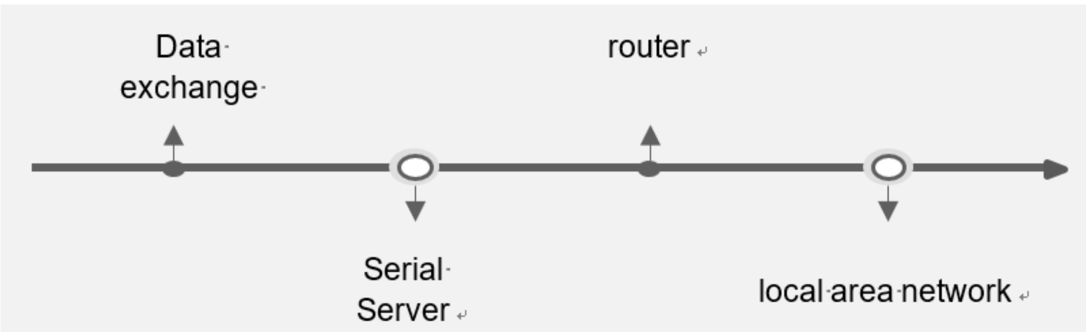

Figure 2: Principle of data collection terminal server

The main purpose of the data conversion interface is to convert the detection signal of the inspection device into a unified format, and access the data collection terminal server through the RS232 interface to realize the data communication between the inspection device and the inspection system. At present, various inspection device manufacturers have added digital interfaces to commonly used measuring devices. However, because different manufacturers have different data specifications, the inconsistency of inspection data is a major obstacle for the construction of quality information management systems. Therefore, the data collection interface module uniformly converts the 16Exd data line interface of the Mahr and Mitutoyo inspection devices to the universal RS232 communication interface, and then sends the collected data to the host through the TCP/IP protocol via the serial server in the data collection terminal server. During the inspection, when the inspector presses the measured data sending button on the inspection devices, the measured data on the inspection device is uploaded to the data collection terminal server through the processor, and then uploaded to the computer for inspection through the data collection terminal. The inspection device data interface has a data output (DATA), a clock output (CLOCK), a ready status output (READY), and a request data port (REQUEST). Their timing diagram is shown in Figure 3.

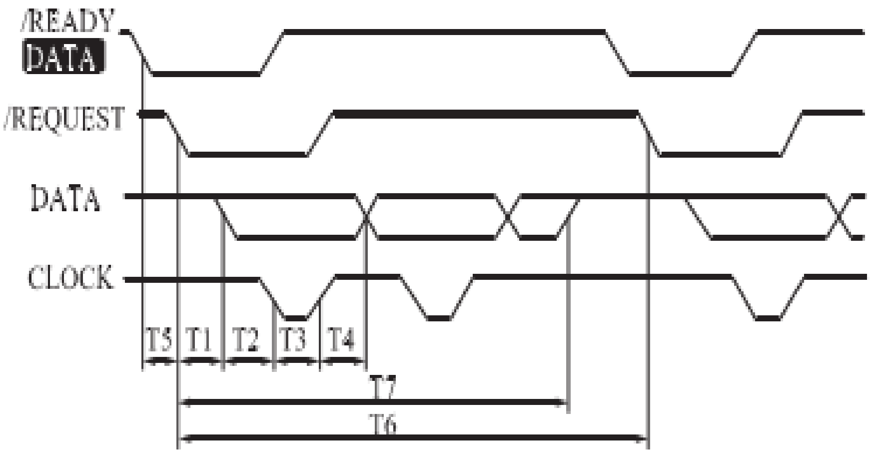

Figure 3: Data output timing diagram

Connect the REQUEST and DATA terminals to the external interrupt port of the microcontroller, and send a low-level request data to the REQUEST to read the return data on the DATA port. The return data format is a string of binary numbers. The format is shown in Table 2. The first 4 bits are the data header. The d5 position is the sign bit of the inspection device, d6-d11 is the data bit of the inspection device, d12 is the decimal point of the inspection device, and d13 is the unit format of the data in millimeters and inches.

Table 2: Return data format

D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13
	Data header			Data								Unit

The wired data conversion interface module uses the 8052 MCU as the main control chip. It inputs the data measured by the digital inspection device to the 8052 MCU through the inspection device interface, and then performs data conversion processing, and finally sends it to the data collection terminal server through the serial port.

In order to facilitate the inspection, the system designs a wireless data transmission module, and the measured data can be transmitted to the data collection terminal wirelessly, which brings more flexibility to the measurement. The CC2530F256 chip is selected, it is an IEEE 802.15.4 wireless communication chip. The CC2530 chip integrates an industry-standard 8051MCU and RF transceiver with system-programmable Flash memory, 8-KB RAM and many other powerful functions. The digital inspection device is connected to the CC2530 through the inspection device interface circuit, and the MCU reads the inspected information of the inspection device, and sends the inspected information of the inspection device to the receiving end through the Zigbee transmission protocol. The receiving end uploads the measured data to the data collection terminal server through the serial port to realize the data collection of the digital inspection device.

4. Results and analysis

The IoT-based parts quality management information collection system is integrated with a variety of inspection devices to automatically extract, collect and store the inspected information of the parts, and provide the big data of the workpiece quality information for the management of the digital factory. According to Table 1, a test platform of the part quality management information collection system was built. The test was divided into 10 groups, and the parts inspection information was tested separately. The reading and writing of each group were performed 3 times, the test results of the host computer were observed and the test results are shown in Table 3. The accuracy of the wired collection module is 100%; the communication distance of the wireless module CC2530 has a great influence on the transmission performance of the system, so it is necessary to test the communication efficiency of the CC2530 at different distances. After testing, there is basically no loss of communication within 15m indoors, which meets the communication requirements of the general workshop. Compared with the traditional parts quality management information collection, it has higher efficiency, faster reading speed, higher accuracy, and other characteristics.

Table 3: Test results

Size	Wired data conversion interface			Wireless data conversion interface		
10.125	10.125	10.125	10.125	10.125	10.125	10.125
-5.632	-5.632	-5.632	-5.632	-5.632	-5.632	-5.632
-8.612	-8.612	-8.612	-8.612	-8.612	-8.612	-8.612
25.001	25.001	25.001	25.001	25.001	25.001	25.001
12.013	12.013	12.013	12.013	12.013	12.013	12.013
10.055	10.055	10.055	10.055	10.055	10.055	10.055
18.012	18.012	18.012	18.012	18.012	18.012	18.012
17.035	17.035	17.035	17.035	17.035	17.035	17.035
30.015	30.015	30.015	30.015	30.015	30.015	30.015
40.011	40.011	40.011	40.011	40.011	40.011	40.011

5. Conclusion

An IoT-based parts quality management information collection system is established in this paper. The system integrates a variety of inspection devices to automatically extract, collect and store the inspected information of the parts, and provides big data of the workpiece quality information for the management of the digital factory. The performance of the system was tested. The test results show that the system had the characteristics of high communication efficiency, fast reading and writing speed and high accuracy. It can meet the requirements of digital factory for the collection of chemical equipment information management system and effectively improve the enterprise’s quality management level, production efficiency and economic benefits. It provides digital inspection information for the construction of digital factory, which had important application prospects.

The system is conducive to the exchange and integration of plant information data in China, it meets the requirements of the era and society for the collection of factory parts information, improves the information management level of the factory, promotes the digital management of the factory, and further improves the economic and ecological benefits of the factory. Therefore, the research and exploration of this system has certain reference significance and application value for the early realization of digitalization, intelligence and automation of factory quality management information collection.

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