Application of network data transmission in ultrasonic automatic inspection system

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Abstract

An ultrasonic automatic detection system, which had the characteristic of transmitting data of ultrasonic inspection signal based on the Ethernet network, was presented in this paper. The system was composed of the detection computer and the operation computer. The detection computer was placed near the workpiece, gathering the ultrasonic probe signal and directly transforming the analog signal into the digital signal in the inspection process. Then the digital signal was transmitted to the operation computer through the network. The operation computer completed the ultrasonic digital signal analysis, processing, display and data storage. This system has high detection efficiency and strong noise proof capability in the work field. This paper also introduced the application of the network transmission method in the multi-channel automatic detection system, such as the entire steel pipe body detection and the axle radial direction flaw detection.

Keywords: Steel pipe, Ultrasonic inspection system, Automation, Network transmission

1. Introduction

As an important method of the industrial UT (Ultrasonic Testing), the automatic ultrasonic inspection system reduced the working strength, guaranteed product quality and increased the labor productivity [1]. The automatic scan inspection of the large area in workpiece was realized, having increased the accuracy and reliability of inspection data. In addition, the digital image created by the inspection software could visually make recognition and judgment to the flaw. Along with the rapid development of computer technology and the widespread application of electrical and mechanic equipment, the automatic ultrasonic inspection system would become the important development direction of ultrasonic inspection.

The traditional automatic ultrasonic inspection system worked on one industrial computer. The computer fulfilled all testing tasks, such as hardware control, data acquisition, transformation, processing, display of the ultrasonic signal, and so on, which made the computer to be overloaded. Simultaneously, the number of total hardware channels was limited because the inner size of the computer limited the number of ultrasonic cards, which reduced the inspection efficiency in the fast massive inspection. In addition, the signal wire between the probe and the computer had to be long in one computer system, which made the automatic ultrasonic inspection system easy to receive the strong electromagnetic noise signal by the environmental electromagnetic interference, mixed in the normal ultrasonic signal. At present, the frequency converter of servo-actuator or stepping motor driver used widely in the automatic ultrasonic inspection system was strong noise source. Moreover, the high-power electric welding equipment used frequently in detection work field also produced the strong noise. The electromagnetic noise seriously disturbed the inspection system, reducing signal-to-noise ratio of the inspection signal greatly [2].

Considering the reasons above, the method of transmitting ultrasonic signal through network was studied in order to solve the problem of the burden and electromagnet noise in the single computer inspection system. The goal was separating the work of inspection task into two or more computers to complete. Using the network to transmit signal data between the computers, the system enhanced the inspection efficiency and overcame the interference of ambient noise. At the same time, because the network system separately completed the work of gathering and processing the ultrasonic signal, the system obtained quicker processing speed compared to a single computer and enhanced the system repetition rate. This method might also use more computers to increase ultrasonic channel numbers in the detection system. In addition, because the analog signal didn’t need to be enlarged for transmission, the electromagnetic signal interference of the electrical equipment to the probe could be suppressed. This network system used one industrial computer to be the detection computer, directly transforming the analog signal produced by the ultrasonic probe into the digital signal. Then the digital data was transmitted to the operation computer through the network. The operation computer processed the data and obtained the inspection result.

This paper introduced the network transmission in the application of automatic detection system through two successful implementation inspection systems as the entire steel pipe body detection and the axle radial direction flaw detection. The application indicated that this method could effectively overcome the noise interference, guaranteeing the detection accuracy.

2. Work principle and realization method

Network transmission system structure was shown in Figure 1, including 3 main modules: data acquisition module in the detection computer, monitor module in operation computer, network transmission module. The function of each module was introduced briefly as follows.

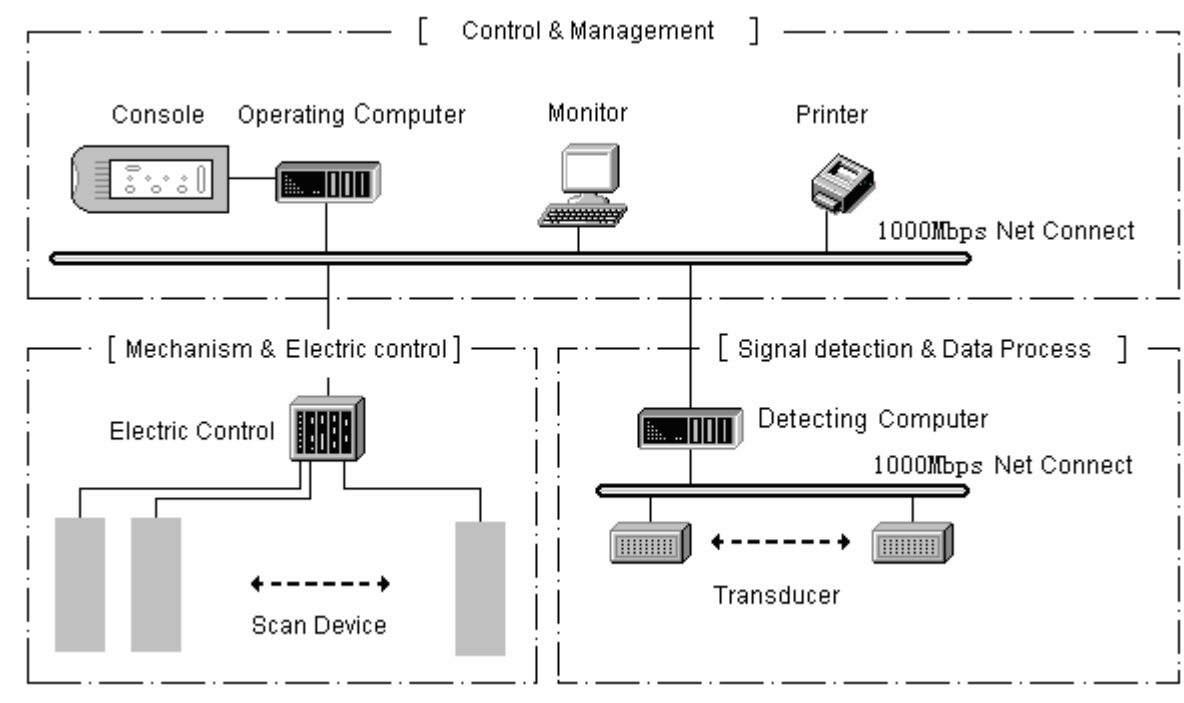

Figure 1. Schematic drawing of network transmission system structure

(1) Data acquisition module:

The data acquisition module was responsible for the data gathering and transformation in detection computer. So long as the connection was established, the gathering data process started unless the operation computer sended out the stop instruction. After suitable data processing, the detection computer transmitted data to operation computer.

(2) Monitor module:

The monitor module was responsible for the data processing and the demonstration in operation computer. When the connection established, the operation computer continued receiving the ultrasonic data transmitted by the gathering module, with the subsequent work of processing the digital data and imaging. Simultaneously, the operation computer could transmit the control instruction, adjusting the working pattern in data gathering module and changing image mode.

(3) Net transmission module:

Using industrial Ethernet of Socket and the Winsocket technology, connection was set up through the ether network [3][4]. Network medium included straight thru wire, relay

concentrator (HUB), optical fiber network and wireless network. The network transmission system used the Gigabit network straight thru hardware of less than 100 meters, guaranteeing the network system transmission speed. Simultaneously, based on the different protocols, the different network connection methods were used and the system efficiency also differed. The detection network system was established on the Customer/Server model, using the protocol of TCP/IP [5]. The reason of choosing the TCP/IP protocol (Socket and the Winsocket technology) was that TCP/IP had characteristic of quick and safe data transmission, as well as its realization flexibility and usability.

3. Example 1: Steel pipe body detection system [6]

The steel pipe which wall thickness was from 10mm to 30mm with the length of 12000mm was inspected using the system. The testing pipe diameter was 406~610mm. The detection system included three main parts: The mechanical scanning equipment, the ultrasonic detection module and the data processing and imaging module, shown in Figure 2.

Figure 2. Picture of entire steel pipe body inspection system

The mechanical equipment was composed by the rotating motor, scanning electrical motor and the actuation device, realizing the functions of rotating steel pipe and moving the probe. The coordinates signal of the circumferential and the axial scanning absolute position was obtained by computer using the revolving encoder. The ultrasonic detection module was composed of the ultrasonic probe, the ultrasonic wave transmitter/receiver module and the detection computer, realizing ultrasonic wave transmitting/receiving, A/D conversion and localizing coordinate position. The ultrasonic wave transmitter/receiver module obtained the digital ultrasonic signal under the control of the detection software. The module analyzed and

computed the digital signal, then transmitted the processed results and the corresponding coordinates to the operation computer through the network. The data processing and imaging module had the function of image processing, automatic analysis of the result and outputting the detection image and data report.

When the detection computer started, the detection application automatically started, waiting the operation computer to send the connection signal. After the connection was established, the detection computer circulated at the status of receiving and sending ultrasonic data. Correspondence of both sides worked at the asynchronous mode. When the operation computer was busy or network was blocked to be unable to receive the data, the detection computer was idle and didn't send data. In case the network was unobstructed, the detection computer transmitted data at once. The operation computer could transmit control signal to the detection computer when the detection parameters changed. When the new ultrasonic data came, the operation computer entered the receiving process. If the new data had not come, the operation computer software could do the work of imaging and information demonstration or other processing work. The detection computer started the inspection procedure after the operation machine sended start signal through the network. The initial processed data was preserved in the memory temporarily and transmitted immediately when network was not blocked. The method not only could avoid escaping inspection in the fast inspection situation, but also could realize the image synthesis and the information demonstration when scanning. After the long time test in the work field, the network system had the high speed and stability of the data transmission.

4. Example 2: Axle radial direction flaw detection system

The system used 24 independent probes to inspect internal flaw of axle and ultrasonic penetration and realized long-distance range ultrasonic data transmission digitization, using the network data transmission method similar to the system above. The automatic ultrasonic detection system and its network transmission structure schematic drawing was respectively showed in Figure 3 and Figure 4. The probes were fixed on probe cabinet, connecting to the signal receiving device with probe wires. The probe cabinet was controlled by the step electrical motor, and its height and sweeping scope could be automatically changed according to the work piece model (user input). The servo electrical motor moved the probe mechanic device to accurate inspection position and distance. All the inspection point data was temporarily stored in the detection computer after gathered and processed. Next the operation computer sended transmission instruction through the network to the detection computer and transmitted all sampling point data to the operation computer. Then the operation computer

post-processed the data, obtained the detection image and evaluated the flaw. Figure 5 was the connection dialog in the detection and data display software interface of the operation computer when the connect button was pressed.

Figure 3. Axle automatic ultrasonic detection system

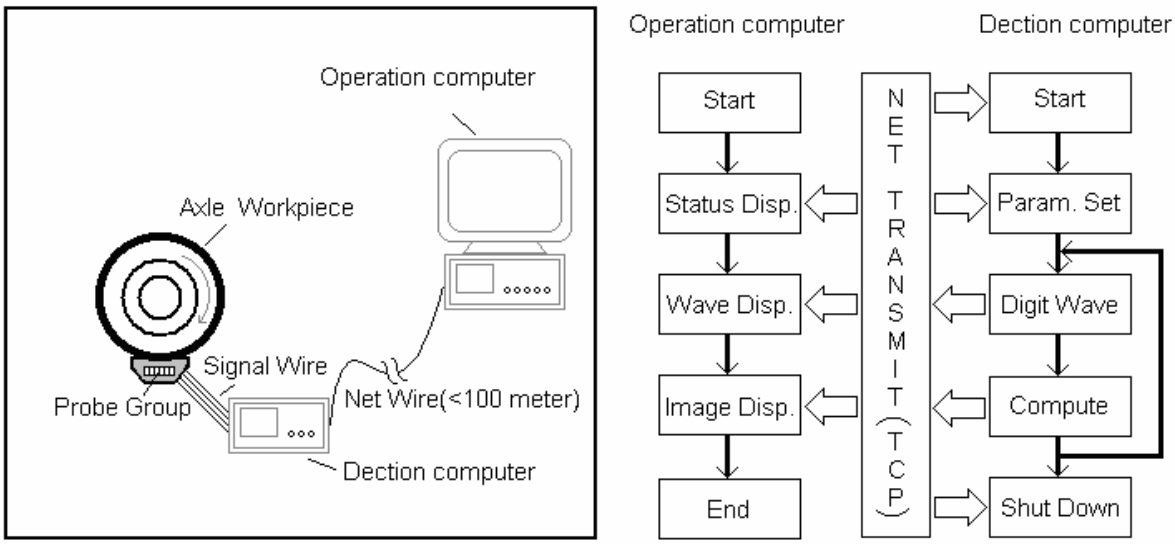

Figure 4. Schematic drawing of network transmission structure

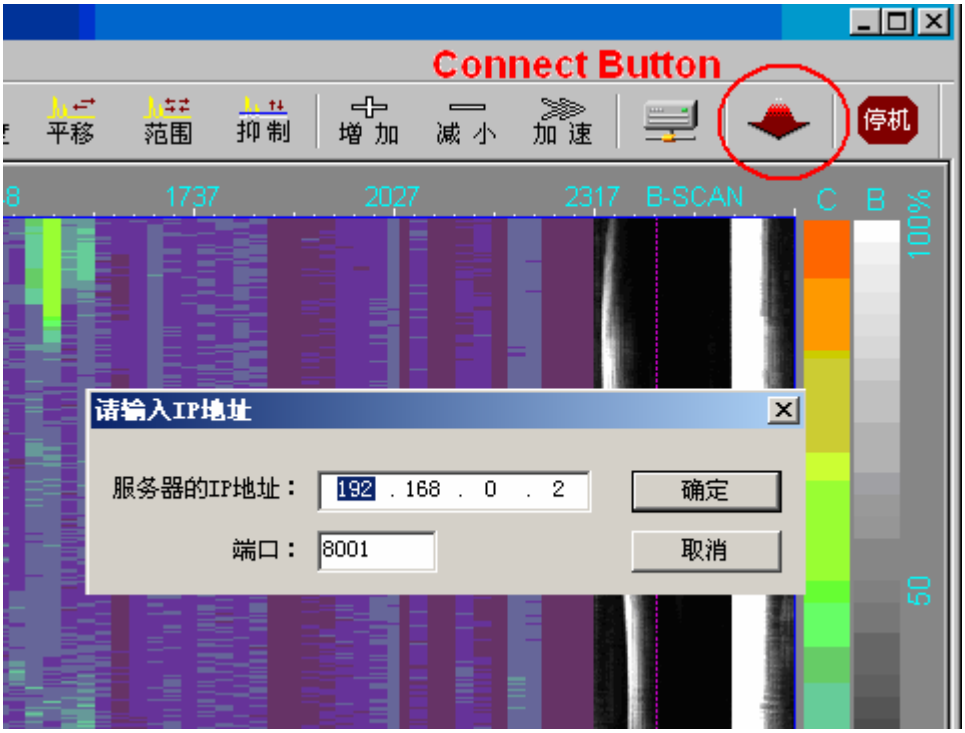

Figure 5. Axle automatic detection software interface relative to network transmission

5. Conclusion

In order to effectively enhance the detection efficiency and noise proof ability, the ultrasonic scanning and image inspection system used the network transmission method. The network transmission method had the several aspect contents as followed:

(1) The network transmission used two or more computers to realize multi-channel scanning and imaging system and eliminate the noise disturbance in the work field.

(2) The network transmission used the Gigabit network hardware and the Server/Client software working mode with TCP/IP protocol, guaranteeing the network system transmission speed and stability effectively.

With the further application of DSP technology in the detection computer, the detection computer reliability would be enhanced and the system failure rate will be reduced. Moreover, the Internet network could also be used to realize remote connection and control. The data could be analyzed in the local work field or the remote place and control inspection process using the Internet network.

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