

Digital Radiographic Imaging Inspection System on The Tube to Tube sheet Welding Joints of Heat Exchanger

Keqin DING , Guang CHEN , Binan SHOU, Xu ZHANG , Donglin HUANG

**China Special Equipment Inspection and Research Institute
Building 2, Xi Yuan, He Ping Jie, Chao Yang District, Beijing 100013, China
Tel: +86-10-59068291, Fax: +86-10-59068319
E-mail: kqding@sina.com Web: <http://www.csei.org.cn>**

Abstract

The tube to tube sheet welding joints of heat exchanger is the most critical joints. A special Nondestructive testing technology was proposed, which is based on the digital radiographic imaging automatic inspection system to the characteristics on the tube to tube sheet welding joints of heat exchanger. A new style Linear Diode Arrays as a device is used to receive ray, which will be fixed on a automatic rotating device, and be led to its rotation of the week through the rotating device to achieve the tube to tube sheet welding joints automatic inspection, finally the whole welding joints image was performed image processing in order to generate testing results. The results showed that this inspection system can be used to quickly and conveniently perform automatic inspection on the tube to tube sheet welding joints inspection , at the same time realize digital radiographic imaging of welds.

Keyword: tube to tube sheet welding joints; digital radiographic imaging; automatic inspection

1

1. Introduction

In the manufacturing process of the heat exchanger, the quality of the tube to tube sheet welding joints has been the most critical joints for quality control .In order to ensure the safe operation of equipment, the tube to tube sheet welding joints need periodic inspections and Supervision.

At present NDT methods of penetrant testing, magnetic particle testing, ultrasonic testing as well as ray film photography and so on are used to detect the welding in the testing process. However penetrant testing can only detect the surface of weld defects, magnetic particle testing can only detect surface and near-surface defects of ferromagnetic materials weld, ultrasonic technology has lower sensitivity to hole defects^[1], ray film photographic method has a series of questions of film storage and environmental pollution and so on.

1.National Scientific and Technical Supporting Programs 01Subject Funded by Ministry of Science & Technology of China During the 11th Five-year Plan (NO. 2006BAK02B01)

Therefore a special ray detection technology is proposed, which is digital imaging automatic inspection methods.

2. System Detection Principle

In view of geometrical shape's particularity of the Plug-in type in the tube to tube sheet welding joints, the small focal point ray source is used, the ray source is anode small focal point X-ray machine or Ir192 γ - ray detection device.

The article introduces 0.6 * 0.6 mm of source size, 2.25 Ci of activity Ir192 γ -ray source detection device, the system detection principle as shown in Figure 1. Ray source enters into the tube from the front tube sheet, and is delivered to the pre-calculated position through focusing device, and makes the Circumferential exposed backward^[2,3], which direction must pass through the tube and the tube sheet welding joints. A new style Linear Diode Arrays as a device is used to receive ray, which will be fixed on a automatic rotating device, and be led to its rotation of the week through the rotating device to achieve the tube to tube sheet welding joints automatic inspection, finally the whole welding joints image was performed image processing in order to generate testing results, thus the system realizes digital imaging .This imaging method can be applied to materials for the carbon steel and low alloy steel and stainless steel tube, such as plug-in tube and tube sheet welding joints inspection.

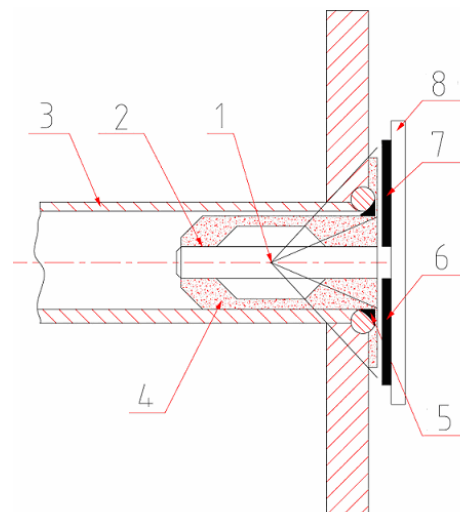


Fig 1. System Detection Principle diagram

- 1.ray source 2. Source drive pipe 3.tube 4. Shield block 5.welding joints
- 6. Counterweight 7. Linear Diode Arrays detector 8. rotating device

3. System Design

The detection system is mainly composed by γ -ray emission and receiving systems, motion control rotating device, the computer and image processing system. System controls circular motion according to the input information (scanning speed, scanning distance, etc.), automatically completes internal quality testing of the tube to tube sheet welding joints.

3.1 γ -ray emission and receiving systems

γ -ray emission and receiving systems is composed by γ -ray emission devices and Linear Diode Arrays detector and so on. the Linear Diode Arrays detector selects the new CMOS imaging technology ,which can simultaneously complete ray receive, the electro-optic to transform and the digitization of the entire process.

3.2 Motion control rotating device

3.2.1 Rotating device

Rotating device is the foundation part which ensures automatic testing process. Its function is driving Linear Diode Arrays detector to realize the steady circumference rotary motion. velocity and accuracy of detector directly influence the efficiency, accuracy and reliability of testing.

The imaging system resolution and the imaging time decide that the imaging system belongs to the low speed movement system, its transmission ratio of 3:1. It is driven to finish circumference rotary motion through the stepper motor and the synchronous pulley. Its structure as shown in Figure 2.

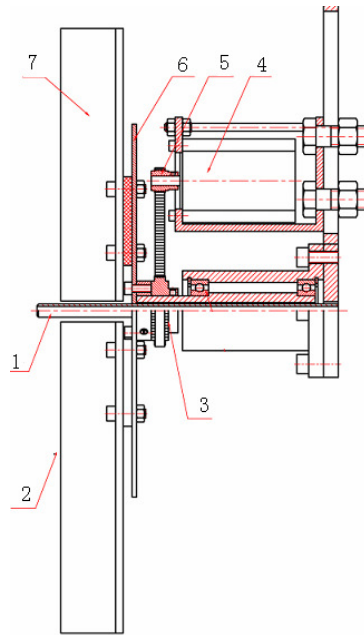


Fig 2 rotating device Structure chart

1. Source drive pipe
2. Counterweight
3. synchronous belt
4. stepper motor
5. synchronous pulley
6. Fixed plate
7. Linear Diode Arrays detector

3.2.2 Control design

In the general industrial automation detection, open-loop control often is driven by a stepper motor. The open-loop control system of stepper motor can meet the requirements that the quality of image is influenced the scanning speed and location accuracy, and which does not need the feedback control in accordance with the weld quality, the maximum resolution and imaging time. In addition, the open-loop control method of the system is selected but also because it has save the cost superiority.

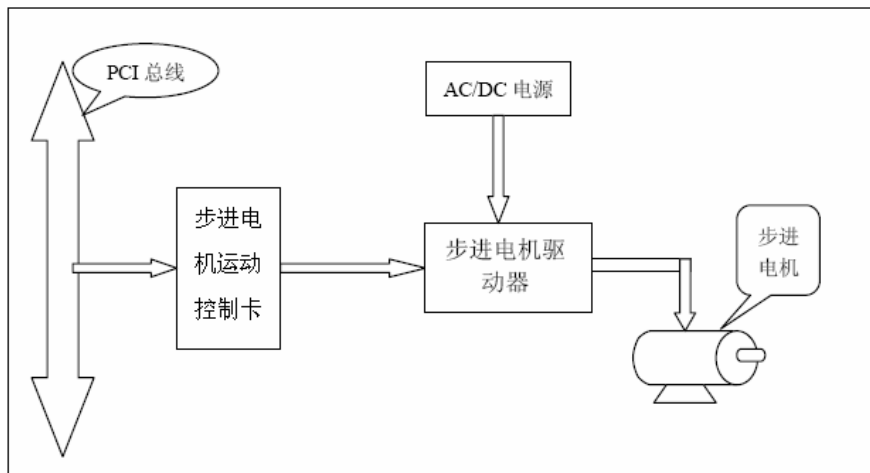


Fig 3 stepper motor control flow

The control system mainly is composed by the computer, movement control card of stepper motor and the driver, its control flow as shown in Figure 3.

Stepper motor'control uses the way of "PC + Motion Control Card", that is, the computer carries on the read-write operation through the control software and transmits the position, the speed and the acceleration order to the control card. movement control card of stepper motor generates pulse sequence according to the computer orders,pulse number (position), frequency (speed) and the frequency rate of change (acceleration) are controlled by computer. Stepper motor driver generates more pulse driving signal to control stepper motor to achieve rotation of positive and negative direction according to received pulse signal. In this system stepper motor drives realize 64 segmentations, which causes the movement to be steady, to be accurate. the system can realize emergency stop by the manual intervention in the operation process.

4 . Image Processing System

Image processing system includes the design of control software and analysis and processing of acquisition image. The system takes WINDOWS XP operating system as the software platform, the VC ++ 6.0 development tools is used to realize the functions.

The system software uses A Chinese language interface as shown in Figure 4. The software can select the rotation of the positive and negative direction, scanning speed, the time of decreasing noise, the range of testing and so on according to technological requirement. At the same time it can realize acquisition image display and image processing function, for example, image enlarging/ reducing, brightness / contrast adjustments ,plus/ negeative demonstration, image decreasing noise, image sharpening, gray histogram statistics and measuring geometry size of defect image, location and grey level and so on.



Fig 4 system software interface

5. Results

The system test results is shown in Figure 5.



Fig 5 system testing result

It showed that this inspection system can be used to quickly and conveniently perform automatic inspection on the tube to tube sheet welding joints inspection , at the same time realize digital radiographic imaging of welds. Of course, our next goal is testing in the field.

References

- [1] QIANG Tian – peng ,One Special Technique of Non - destructive Testing—Radiographic Testing on Tube to Tube - sheet Welds , Pressure Equipment and Systems,Vol. 21. No.1 2004

- [2] LI Yan, Non Destructive inspection of pressure vessels: Radiographic technique(□),
Nondestructive Testing, Vol. 26. No 3 2004
- [3] YAO Xuan dong, RADIOGRAPHIC INSPECTION OF THE FILLET WELD IN THE
TUBE AND TUBE SHEET OF HEAT EXCHANGER, Nondestructive Testing, Vol.25
No. 12 2003