

The Progress of TOFD Technique in China

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Abstract

Time-of-flight diffraction (TOFD) technique was introduced into China in the start of 21st century. Now there are more than 20 boiler and pressure vessel manufacturers, pressure piping installation companies and inspection agencies or companies engaged in TOFD research and application in China. More than 100 inspectors have been trained and qualified for TOFD. 2 pressure vessel manufacturers and 4 inspection agencies have finished their testing standards. The national testing standard has been drafted. One ultrasonic equipment manufacturer has developed TOFD testing equipment. The research and application fields include equipment developing, TOFD signals analysis and processing, pressure equipment and hydropower station equipment testing, and so on. This paper reviews the history, testing personnel, standards, equipment, research and application area of TOFD in China.

Keywords : TOFD, Ultrasonic test, Review, Pressure equipment.

1 Introduction

Time-of-flight diffraction (TOFD) technique was firstly put forward by Dr. Mauric Silk in 1977^[1]. TOFD technique was widely applied to inspection of equipment in petroleum and natural gas industry, petrochemical industry, chemical industry, power industry, nuclear power industry and transportation industry in the world in 1990s^[2-6].

In 2001, the first TOFD ultrasonic testing instrument was imported by China First Heavy Industry Group Ltd. (CFHI) in China. It was used to test the weld of two hydrogenation reactors with wall thickness of 340mm for liquefaction of coal.

In 2002, several TOFD ultrasonic testing instruments were imported from RD TECH of Canada by some pipeline installation companies. These equipment were used to test the butt welds of the natural gas pipeline from northwest to east of China.

In 2003, the first TOFD testing instrument with manual scan was developed by China Special Equipment Inspection Institute (CSEI). It was used to test repairing weld for above-mentioned natural gas pipeline.

In 2004, the first TOFD testing standard of enterprise was drafted by CFHI. It was approved by China Standardization Technical Committee on Boiler and Pressure Vessel in that time.

In 2006, TOFD testing technique was approved to apply to test the weld during hydropower station equipment installation in three gorges in Yangzi River in China.

In 2007, General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) from Chinese government issued a regulation to allow TOFD test method instead of radiography test for pressure vessel which wall thickness is more than 60mm. The training and examination for TOFD testing personnel were performed in this year.

Figure 1 shows the principle of TOFD test technique. The purpose of this paper is to review the situation of TOFD technique in China.

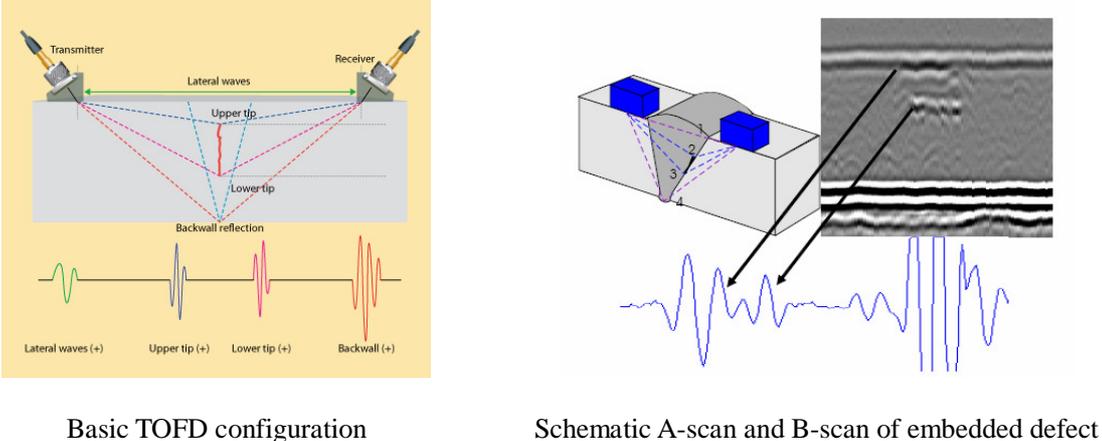


Fig 1 The schematic principle of TOFD technique

2 Training and Examination of Personnel

There are 8 governmental and industrial sectors to carry out qualification and certification of NDT personnel for different kind of industrial equipment and products in China^[7]. The qualification and certification committee of non-destructive testing personnel for special equipment (including in boiler, pressure vessel, pressure piping, elevator, crane, cableway and amusement ride) is the only organization who has performed training and examination for TOFD testing personnel. Total 5 classes have been carried out since March, 2007. Total 128 inspectors from 21 boiler and pressure vessel manufacturers, pressure piping installation companies and inspection agencies or companies have been qualified and obtained their TOFD level II certificate.

The applicant for TOFD level II should have UT level II certificate over 4 years. The contents of TOFD level II course include in principle of TOFD technique, ultrasonic equipment and probes used for TOFD technique, equipment operation and set-up procedure, preparation of testing procedure, interpretation and analysis of data, basic analysis of

discontinuities, detailed analysis of discontinuities, limitations of the TOFD technique and writing test report. The examination modes TOFD level II personnel include in writing examination for testing principle and preparation of testing procedure, operation examination for test plates with welding defects, interpretation and analysis of a set of discontinuities data.

3 The Situation of TOFD Ultrasonic Testing Equipment

Most of TOFD ultrasonic testing equipment import from abroad. More than 100 sets of equipment have been imported from RD Tech of Canada, Sonotron NDT of Israel and AIS of USA since 2001. The models of these TOFD ultrasonic testing equipment are Omniscan MX of RD Tech, Isonic 2005 of Sonotron NDT and NB2000-MC of AIS. Over 30 sets of equipment were sale in Chinese market last year.

In 2005, Wuhan Zhongke Innovation Company developed one commercial TOFD ultrasonic testing instrument with HS800 as the model number in China. 5 sets of HS800 have been sale since that time. Figure 2 is the picture of HS800.



Fig 2 HS800 TOFD ultrasonic testing instrument

The main specification data of HS800 hardware are as follows:

Number of pulsers/receivers: 2, 4 or 8

Pulse output: -400V

Receiver gain range: 0-110 dB, by steps of 0.1dB, 2.0dB and 6.0dB

Mode: PE(pulse-echo), PC (pitch-and-catch), TT (through-transmission)

Input impedance: 25 Ω , 500 Ω

Bandwidth of the system: 0.5~15MHZ

Rectifier: Both, positive, negative

Gates quantity: 2

Refresh rate: 125HZ

A-scan acquisition rate (TOFD): 125M

I/O ports: USB, LAN, VGA

The main function and features of HS800 are as follows:

A scan: Display the ultrasonic signal amplitude as a function of time.

B scan: Display the time-of-flight of the ultrasonic signal as a function of probe displacement.

Single channel or multi-channel TOFD non-parallel and parallel scan: suitable for testing welds with $6\text{mm} < \text{wall thickness} \leq 60\text{mm}$.

P scan: Single channel transverse wave or surface wave PE non-parallel and parallel scan

4 The Situation of TOFD Testing Standard

The earliest TOFD testing standard in the world was published by British Standard Institute (BSI) in 1993^[8]. In 1996, ASME Boiler and Pressure Vessel Code Case No.2235-8 stipulated that ultrasonic testing method (including in TOFD) could be used to substitute radiography test method required by ASME code. The recent version of this code case was revised in 2005. Based BS 7706-1993, CEN drafted its first TOFD testing standard which is ENV583-6:2000^[9]. In 2004, CEN published TOFD standard for examination of welds and ASTM published its first TOFD testing standard^[10,11].

The Chinese national TOFD testing standard which is “Non-destructive testing - Ultrasonic examination - Time-of-flight diffraction technique as a method for detection and sizing of discontinuities” just has been drafted this year. This draft is being reviewed by China Standardization Technical Committee on Non-destructive Testing. The TOFD testing standard for pressure equipment had been drafted in 2007. This draft had been reviewed by China Standardization Committee on Boiler and Pressure Vessel (CSCBPV). It will be published at the end of this year.

Due to there was not national TOFD testing standard, some pressure vessel manufacturers and inspection agencies have established their TOFD testing standards. The first TOFD testing standard of enterprise was drafted by CFHI and was approved by CSCBPV in 2004. In 2007, the TOFD testing standards of another pressure vessel manufacturer and four inspection organizations were approved by CSCBPV. All of these TOFD testing standards are used to test the boilers, pressure vessels and pressure piping.

5 Research and Application Field of TOFD Technique

The research and application fields of TOFD technique include equipment developing, TOFD signals analysis and processing, boiler and pressure vessel fabrication test, pressure pipeline installation test and hydropower station equipment test in China. More than 10 boiler and pressure vessel manufacturers have bought TOFD ultrasonic testing equipment to take test for their products during fabrication. More than 5 inspection agencies have offered TOFD ultrasonic testing service.

Wuhan Zhongke Innovation Company and CSEI are jointly developing new generation TOFD ultrasonic testing equipment. This new equipment can test welds of $6\text{mm} < \text{wall}$

thickness \leq 400mm with multi-channel.

China First Heavy Industry Company (CFHI) is the biggest manufacturer for heavy pressure vessels in China. CFHI have used Omniscan MX to perform TOFD ultrasonic test for 14 hydrogenation reactors and high pressure heat exchangers with thickness between 113mm and 340mm since 2001.

China Special Equipment Inspection Institute (CSEI) is the only one national inspection and research organization for pressure equipment in China. CSEI used TOFD ultrasonic testing instrument itself developed to test several hundreds repairing welds for the natural gas pipeline from northwest to east of China in 2003. Since 2007, CSEI have used Omniscan MX of RD Tech, Isonic 2005 of Sonotron NDT and HS800 of Wuhan Zhongke to perform TOFD ultrasonic test for total 36 reactors and heat exchangers, 22 spherical storage tanks with 400 ~ 3,000m³ volume and 14 oil storage tanks with 100,000m³ volume. The thicknesses of these pressure vessels and storage tanks are between 28mm and 340mm.

Some users of RD Tech have used Omniscan MX to test 8 drums of 5 boiler manufacturers. Some users of Sonotron NDT have used Isonic 2005 to test hydropower station equipment in three gorges and oceanic oil platform.

6 Conclusions

(1) TOFD technique was introduced into China in 2001. Now it has been successfully applied to inspection of boiler and pressure vessel fabrication, pressure piping installation, and hydropower station equipment installation in China.

(2) Special equipment (including pressure equipment) industry has carried on training and examination for TOFD testing personnel. Total 128 inspectors from 21 boiler and pressure vessel manufacturers, pressure piping installation companies and inspection agencies or companies have been qualified and obtained their TOFD level II certificate.

(3) More than 100 sets of single channel or multi-channel TOFD testing equipment have been imported from Canada, USA and Israel. One company from China had developed model HS800 TOFD ultrasonic testing equipment in 2005. This model equipment has been sale in the market. The multi-channel TOFD testing equipment is being developed.

(4) 2 pressure vessel manufacturers and 4 inspection agencies have established their TOFD testing standards. The national testing standards have been drafted.

(5) Due to TOFD testing method has advantage such as quick testing speed, high sensitivity, accurately measuring depth and height of defects, no harm for inspectors and low expense comparing with RT, it will be more and more widely used in China.

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