Application of Advanced UT in Nuclear Power Plant Inspection

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1. Introduction

Sae-An Engineering has been doing PSI(Pre-service Inspection) and ISI(In-service Inspection) more than 20 years in Korean NPP(Nuclear Power Plant). UT (Ultrasonic Testing) as a part of NDT(Nondestructive Testing) is the best method for volumetric examination in performing PSI/ISI on piping welds and components to confirm their integrity at NPP. Recently, some advanced UT techniques are developed and used to NPP examination.

I describe these some advanced UT techniques briefly in this paper.

2. TOFD UT Technique

2.1 Concept of TOFD UT Technique

TOFD(Time of Flight Diffraction) UT technique uses ultrasonic beam diffraction from the tip of crack embedded in the examination volume. It has characteristics of sensitiveness to shallow and tight crack. Generally, TOFD technique needs two ultrasonic probes as one for transmitting, the other for receiving signal. The diffraction wave of the crack is generated from the tip if the crack is in the examination volume. By measuring flight time of the diffraction wave, a depth of the crack tip is calculated using trigonometry.

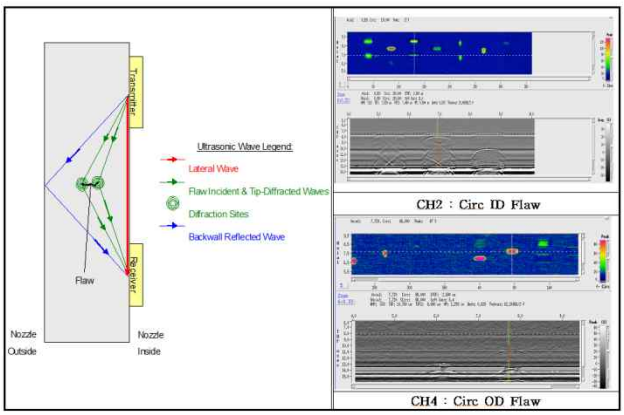

Fig. 1 Concept of TOFD Technique and Signals from RVHP Examination.

2.2 Application in NPP Maintenance

TOFD UT technique is used for RVHP(Reactor Vessel Head Penetration) examination in NPP because it is sensitive for detecting shallow and tight crack in the RVHP welds and base material of inconnel.

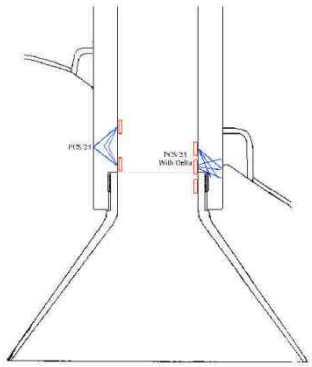

Fig. 2 Configuration of RVHP weld examination.

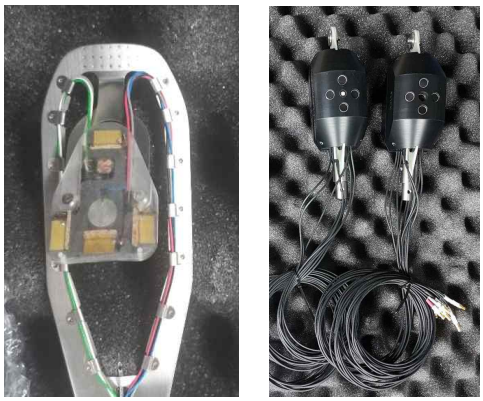

Fig. 3 TOFD probes for RVHP examination.

UT signal of TOFD has different shapes depending on the location of crack. For the ID located crack, lateral wave breaking is observed (No lateral wave is observed in crack location). And for the OD located crack, back wall signal disturbance can be observed. An echo-dynamic line of the crack is observed in the intermediate refracted signal.

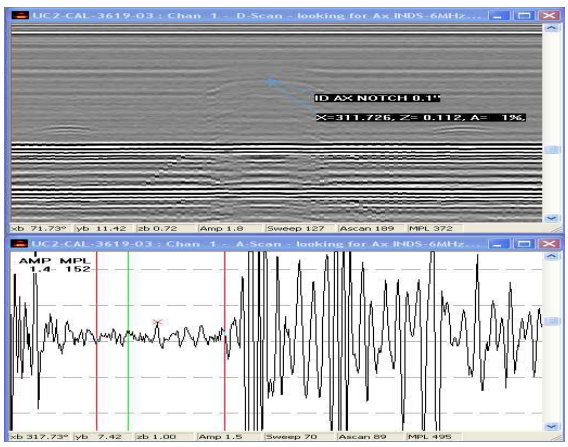

Fig. 4 Example of ID located crack signal.

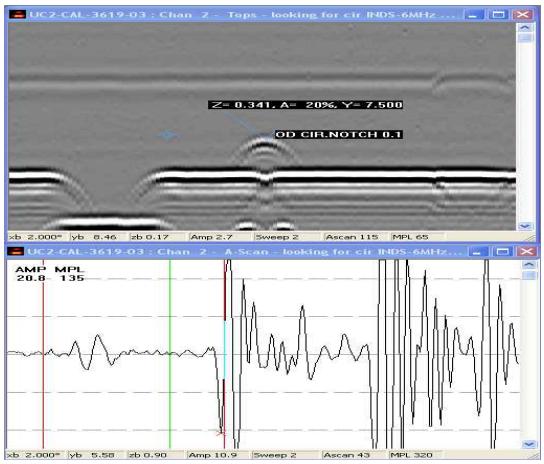

Fig 5 Example of OD located crack signal.

3. PAUT Technique

3.1 Characteristics of PAUT

PA(Phased Array) UT probe uses multiple arrayed elements of transducers. Each of the elements can be pulsed independently. Ultrasonic beam can be steered or focused by the control of the pulse timing. PA probe can make multiple incident angles and focused ultrasonic beam at certain depth by using pulse timing (delay) control in software.

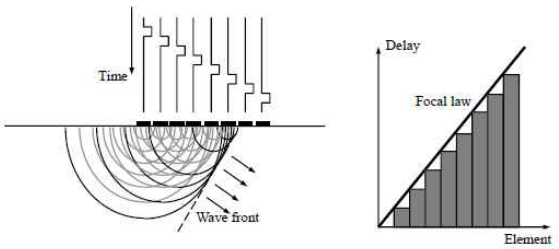

Fig. 6 PA Probe Ultrasonic Beam steering (Delay Control)

PA UT has many advantages for complex figured volumetric examination and highly reliable detection-ability by this wave angle control and focusing beams.

However PA UT is required comparatively expensive probes and equipment with skilled examiner. PAUT has also other disadvantages of low scanning speed due to large acquiring data size and some limited access due to big probe size.

There are some brands of PAUT equipment named OmniScan MX series by GEIT, and TOPAZ and DynaRay by ZETEC.

3.2 Application in NPP Maintenance

PAUT is applied to examinations for reactor pressure vessel welds, dissimilar metal welds with high attenuated material such as nozzle weld or overlaid weld of pressurizer, and turbine blade with complicated configure.

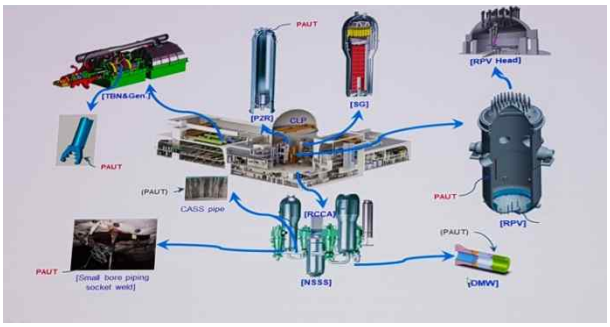

Fig. 7 PAUT Application in NPP.

For reactor pressure vessel weld and dissimilar metal weld examination, data analyst in NPP needs to have PDI qualification per ASME/KEPIC code in Korea.

Reactor pressure vessel weld examination is performed with remotely operated scanning robot in the water.

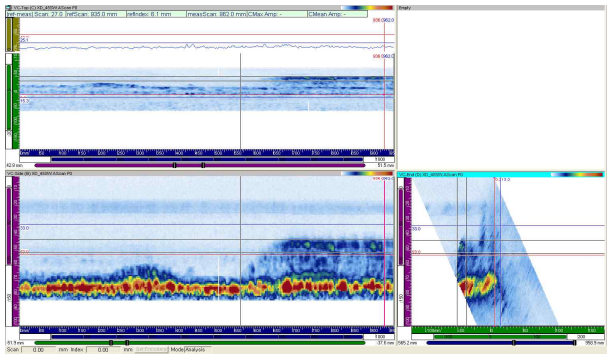

Fig. 8 Example of PAUT data.

Dissimilar metal weld examination is performed from outside surface of piping weld using manual or encoded scanner.

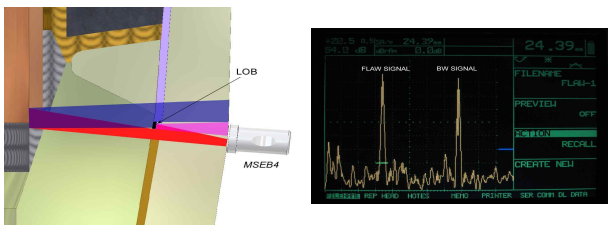

Fig. 9.Overlaid weld signal of conventional UT with A-scan

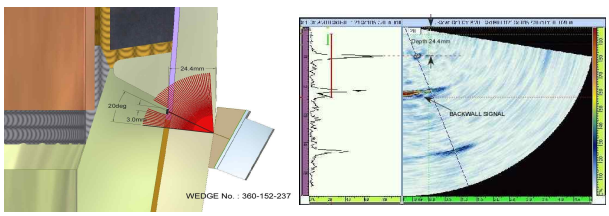

Fig. 10 Overlaid weld signal of PAUT with Sectorial scan and A-scan

As shown in the examples above, PAUT technique is also very advantageous to show detected crack visually by using both sectorial scan and A-scan data.

4. Conclusions

UT is the most effective NDT method to check their abnormality on piping welds and components in NPP.

Therefore, new techniques of UT are still being developed and applied to piping weld and component examination in Korean nuclear power plant as the most reliable examination.