A Study on Flaw Sizing and Location Estimation in Tapered Dissimilar Metal Welds on Nuclear Power Plants

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1. Introduction

The dissimilar metal welds (DMW) were used to join the carbon steel reactor pressure vessel to the stainless steel main recirculation piping or reactor coolant piping. The safe end was used as the same or similar metal at an attachment area. The DMW requires a periodic inspection because it is highly susceptible to primary water stress corrosion cracking (PWSCC). However, the inspection of DMW for NPPs in Korea is difficult owing to the physical constraint as well as the diffraction scattering and/or reflection on the weld interface when using the conventional ultrasonic technique. Also, manual procedure only deals with the flaw detection and length sizing. The purpose of this study is the development of procedures for accurate defect assessment in DMW.

Fig. 1. Illustration of DMW in site

2. Inspection technique

The phased array ultrasonic testing (PAUT) can reduce the inspection time and increase the flaw detection sensitivity by using the multiple elements against conventional UT. The advantages of PAUT are the steering and focusing of the ultrasonic beam[1].

Dissimilar metal weld in the reactor coolant system is difficult to perform a consistent inspection due to poor accessibility and signal sensitivity. Furthermore, NPPs in Korea have a wide range of diameter and nozzle for DMW (2.2 ~ 37.2 inch). In this study, a manual scanner was developed in order to reduce the uncertainty and it was used in conjunction with PAUT transducer.

3. Experimental setup

The selection of focal law is important because the inspection is performed through the buttering, weld zone, and weld interface. The transducer with nominal frequencies of 1 MHz ~ 2 MHz was used considering thickness of the weld zone or piping[2]. The scan distance was approximately set from 1 inch to 3 inch in order to satisfy the inspection volume at a central angle of the sectorial scan as shown in Figure. 2.

Table I: Specification of PAUT transducer

Probe #	Frequency (MHz)	Matrix
1	1.5	2 × 16
2	2	2 × 16
3	1	2 × 16
4/5	1.5	4 × 7

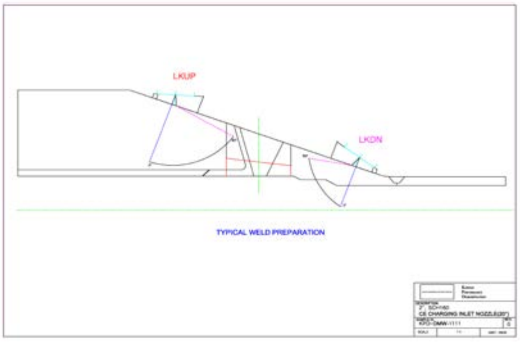

Fig. 2. Examination volume for circumferential defects.

The focal laws configured for tapered welds were entered into portable device (OmniScan, ZETEC Inc.) for applying to field inspections. The acquired signal information of DMW was stored in data storage unit and it can be analyzed using UltraVision 1.1Q5 (ZETEC Inc.) analysis software.

4. Results

4.1. Data evaluation

The acquisition data were evaluated by UltraVision software and the data can be converted to RDT file, which is ultravision data format using OmniScan Converter 1.9. The flaw evaluation screen consists of 5 panes of A Scan (Raw signal), B Scan (Side view), C Scan (Top view), D Scan (End view), and S Scan (Sectorial view). Typically, the length of flaw could be assessed by B, D, C Scan and the depth of flaw could be evaluated by A, S Scan. Figure. 3 shows the analysis screen of ultrasonic signal[3,4].

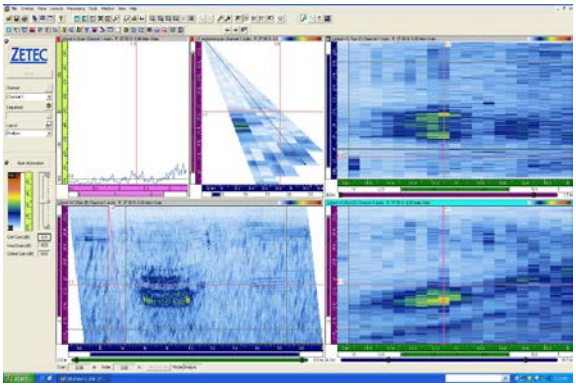

Fig. 3. Signal analysis screen of UltraVision

4.2. Measurement of flaws

Length measurement is carried out a test in both directions based on the weld center. The PAUT probe moved along the flaw and size was measured by Decibel drop technique. Depth sizing of flaw shall be obtained by Absolute Arrival Time Technique when acquiring the best tip response from near or far side of the weld. In addition, the proper setup of focal depth is required for accurate measurement according to the expected flaw height.

5. Conclusion

This research aimed to increase the reliability and sensitivity of flaw sizing in dissimilar metal welds. The current manual ultrasonic technique for tapered DMW (KPD-UT-10) is mainly being applied to the length sizing and detection of flaws. In order to estimate the growth of the defect, depth sizing of flaws is required.

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