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Assessment of Ultrasonic Amplitude for Air Filled and Water Filled Piping Weld in Nuclear Power Plant

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1. Introduction

The periodic inspection of piping and pressure vessels welds in nuclear power plant has to provide reliable result related to weld flaws, such as location, maximum amplitude response, ultrasonic length, height and finally the nature or flaw pattern. The founded flaw in ultrasonic inspection is accepted or rejected based on these data. Specially, the amplitude of flaw response is used as basic parameter for flaw sizing and it may cause some deviation in length sizing result [1].

Currently the ultrasonic inspections in nuclear power plant components are performed by specific inspection procedure which describing inspection technique include inspection system, calibration methodology and flaw characterizing [2]. To perform ultrasonic inspection during in-service inspection, reference gain should be established before start ultrasonic inspection by requirement of ASME code. This reference gain used as basic criteria to evaluate flaw sizing. Sometimes, a little difference in establishing reference gain between calibration and field condition can lead to deviation in flaw sizing. Due to this difference, the inspection result may cause flaw sizing error. Therefore, the objective of this study is to compare and evaluate the ultrasonic amplitude difference between air filled and water filled pipe in nuclear power plant. Additionally, the accuracy of flaw sizing is estimated by comparing both conditions.

2. Methods and Results

2.1 Test System and Specimen

The test system was configured as shown in Figure 1.

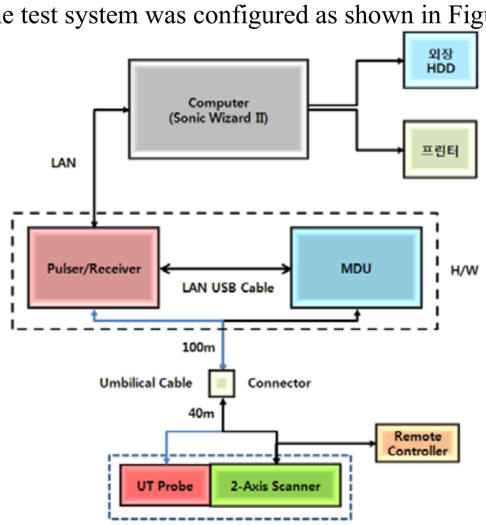

Fig. 1 Ultrasonic test system configuration layout

The test system consist multi channel ultrasonic pulser-receiver, motor drive unit, 2-axis scanner and computer. The computer installed software which can control the system and acquire ultrasonic signals. The central frequency of ultrasonic transducer is 2.25 MHz and the element diameter is 9.5 mm.

The test conditions for the experiment are as follows:

- Gain: 27 dB
- Pulse width: 240 µs
- PRF: 50 Hz
- HPF: 1 MHz
- LPF: 10 MHz
- Sampling: 50 MHz
- Scan resolution/speed: 0.05/40
- Index resolution/speed: 0.5/25

Test specimen made by stainless 304 austenitic material pipe containing fatigue crack. Table I shows flaw details for this study.

Table 1 Fatigue flaws information, mm

No	Orientation	Location	Length	Depth	% depth
1	Circ	Up	3.30	0.94	63
2	Circ	Up	0.43	0.12	8.4

2.2 Test Conditions and Procedure

Test specimen positioned vertically on rubber plate to prevent water leakage. Fig. 2 shows experimental setup to inspect pipe weld. First, ultrasonic testing experiment is performed at normal condition without water inside of pipe.

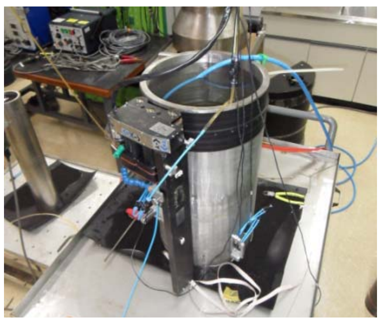

Fig. 2 Experimental setup for UT data correction

Then the water is supplied to inside of pipe to fill with water. After filled with water in pipe, ultrasonic data corrected with same condition. To study the amplitude difference on inspection angle, angle of the ultrasonic transducers selected to 0°, 45° and 60°. These angles are changed by replacing detachable wedge

2.3 Result and Discussion

The amplitude evaluation performed on acquired ultrasonic data. Sonicview that was developed by KHNP-CRI is used as ultrasonic data analysis software. The data analysis done by several ultrasonic display modes include A-scan, B-scan, C-scan and D-scan. First, the highest amplitude conformed by C-scan image that showing flaw's top view. From that position, highest amplitude values measured from A-scan wave form. The amplitude value on air and water condition is measured at the same scan and index coordinate.

The maximum ultrasonic amplitude measured in air condition for flaw #1 is 63.7% full screen height and the maximum amplitude in water condition is 62.34% full screen height for 0° condition.

Fig. 3~4 shows ultrasonic signals acquired at air condition and water filled condition. From the both images, the flaw response is similar on both conditions.

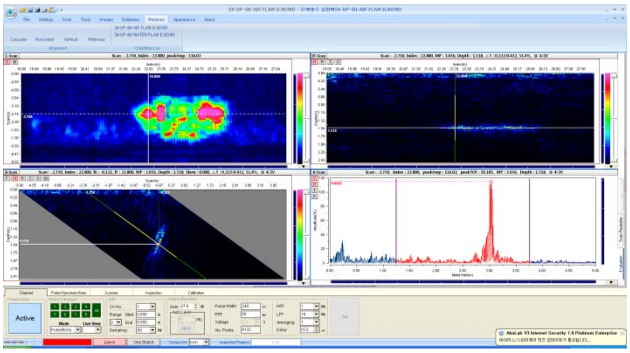

Fig. 3 Ultrasonic single from the air condition at 60°

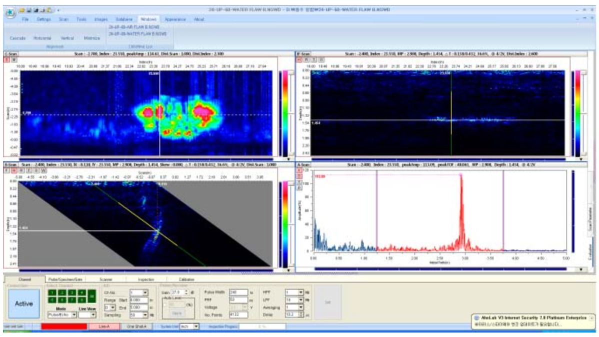

Fig. 4 Ultrasonic single from the water filled condition at 60°

Table II shows summary of amplitude measurement result from the Fig. 3 and Fig. 4. From measurement results, we can notice the amplitude difference between air and water filled conditions. The maximum amplitude difference is within 1 dB for all inspection angles. Based on the amplitude measurement results, length of the each flaws are characterized by dB drop method.

Table II Amplitude measurement results, %FSH

Flaw no	Amplitude			
	Condition	0°	45°	60°
1	Air	63.70	111.97	119.3
	Water	62.34	109.51	113.19
	Difference	0.19 dB	0.19 dB	0.46dB
2	Air	63.70	112.56	108.98
	Water	62.34	107.40	104.18
	Difference	0.19 dB	0.41dB	0.39dB

* Note : Difference is the logarithmic scale between air and water.

In this study, 12 dB drop method is applied to measure the flaw length. Table III shows the flaw length sizing result according to test conditions.

Table III Amplitude measurement results, mm

Flaw no	Condition	Measured flaw length	
		45°	60°
1	Air	90.17	90.17
	Water	85.09	87.63
	Difference	5.08	2.54
2	Air	21.59	15.24
	Water	19.05	15.24
	Difference	2.54	0

From the above table, we can calculate the length sizing error based on 12 dB drop method. Even though the amplitude difference maintain within 1 dB, resulted length sizing error on both conditions could be reach at 10% error.

3. Conclusions

In this study, ultrasonic amplitude differences between air and water filled pipe are evaluated by real test condition. Consequently, we propose the following results.

1. The ultrasonic amplitude difference between air and water filled condition is measured by lower than 1 dB.
2. The flaw length sizing error between air and water filled condition shows maximum 10% based on 12 dB drop method even thought the amplitude difference is 1 dB.

REFERENCES

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[2] A. Birks, Nondestructive Testing Handbook, American Society for Nondestructive Testing, pp. 575-584,1991