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Evaluation of Effect by Internal Flow on Ultrasonic Testing Flaw Sizing in Piping

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1. Introduction

Most of the piping welds in nuclear power plants are inspected periodically using ultrasonic techniques to detect service-induced flaws such as IGSCC cracking. The inspection results provide information 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 information. Specially, the amplitude of flaw response is very important to estimate the flaw size [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 methodology [2]. To perform ultrasonic inspection during in-service inspection, reference gain should be established before starting 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. In this study, the ultrasonic amplitude difference between air filled and water filled piping in nuclear power plant is compared by modeling approach

2. Methods and Results

2.1 Ultrasonic Modeling

Ultrasonic modeling was performed on the ultrasound flaw response. The CIVA[8] of CEA, a French firm, was used for modeling and the Kirchhoff approximation solution was applied. Figure 1 shows the 3D model of probe and flaw location on pipe specimen. In this study, the frequency of UT probe is 2.25 Mhz and diameter of probe is 0.375"

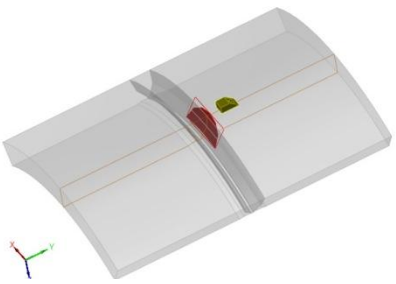


Fig. 1 Ultrasonic 3D model for ultrasonic flaw response calculation depend on internal medium.

The modeling parameters which was used in CIVA software is below.

- Component –Geometry type : 2D CAD
- Component –Material : Stainless Steel
- Probe – Element : Single element
- Test -Coupling medium : water
- Test -Bottom medium : Air
- Computation – Incident Field : On-line beam/3D computation/Accuracy 1
- Computation – Option : T-wave, Half skip

In this study, stainless 304 austenitic material pipe containing fatigue crack is use for modeling.

Table 1 and table 2 show detail information of pipe specimen and flaw details for this study.

Table 1 Pipe specimen information, Inch

No	Material	OD	Thickness
1	Austenite S/S	12	0.688
2		24	1.5

Table 2 Fatigue flaws information, Inch

No	Type	Location	Length	Depth	% depth
1	M	Down	0.851	0.308	45
2	T	UP	1.394	0.478	70
3	T	Down	2.676	0.876	58
4	T	Up	2.88	0.947	63
5	T	Down	1.337	0.446	29
6	T	Up	0.386	0.127	8.4

T ;Thermal Crack, M :Mechanical Crack

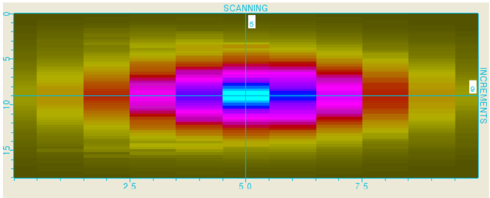
2.2 Result and Discussion

The modeling results for air filled and water filled condition are compared to evaluate the effectiveness of amplitude and sizing. Fig. 2 shows C-scan(top view) of computation results. From the computation results, the maximum amplitude is measured and flaw length is sized by 12 db drop method.

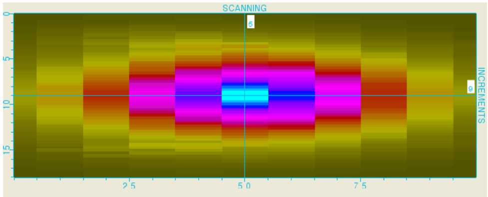
The data analysis done by several ultrasonic display modes include A-scan, B-scan, C-scan and D-scan. First, the highest amplitude conformed by C-scan image that showing flaw's top view. From that position, highest amplitude values measured from A-scan wave form. The amplitude value on air and water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

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

Additionally, the tip echo shows same amplitude response.

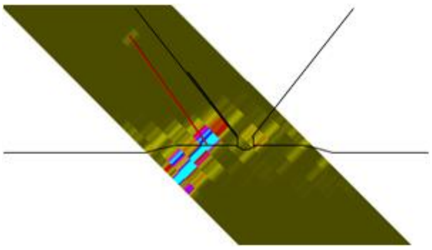


(a) Air filled

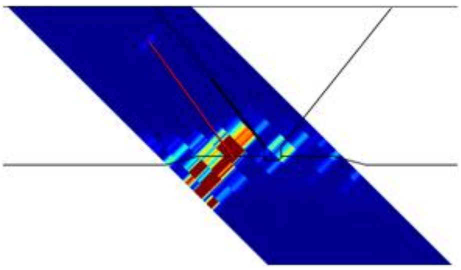


(b) Water filled

Fig. 2 The 3D modeling result for air filled and water filled condition



(a) Air filled



(a) Water filled

Fig. 3 B-scan(side view) signal of ultrasonic modeling results : (a) air and (b) water

Table 3 shows summary of amplitude measurement result from the modeling result. From measurement results, we can notice the amplitude difference between air and water filled conditions. The maximum amplitude difference is within 1.0 dB for inspection angles.

Table 3 Amplitude measurement results, %FSH

Flaw no	Amplitude	
	45°	60°
1	-1.26	-1.48
2	-1.29	-1.47
3	-1.53	-1.49
4	-1.43	-1.50
5	-1.53	-1.37
6	-0.81	-0.7

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

Table 4 shows the amplitude deviation with actual flaw length according to test conditions. From this result, the longer flaw length shows more amplitude deviations.

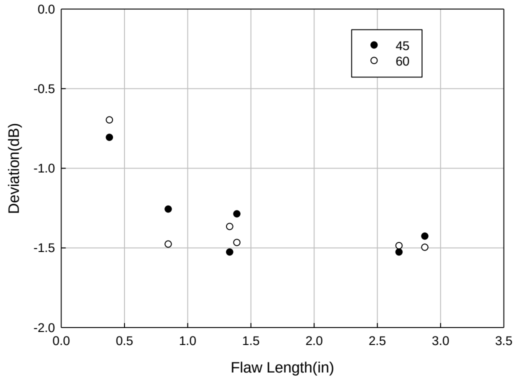


Fig. 4 Amplitude measurement deviation according to flaw length with inspection angle(unit:in)

From the modeling results, the flaw length sizing preformed based on 12 dB drop method. Even though the amplitude difference maintain within 1 dB, resulted length sizing error on both conditions are closely same. To accurately evaluate the effective of ultrasonic test result for internal mediums of piping, the actual experiment by automatic ultrasonic testing is necessary.

3. Conclusions

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

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

REFERENCES

[1] B.S Yoon, Procedure Development and Qualification of the Phased Array Ultrasonic Testing for the Nuclear Power Plant Piping Weld, Journal of the Korean Society for Nondestructive Testing, Vol. 3, N0. 4, pp. 317-313, 2010

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