Transactions of the Korean Nuclear Society Spring Meeting
Chuncheon, Korea, May 25-26 2006

Reflection Characteristics of a Notch in the Plate by a Magnetostrictive Sensor Technique

Yong-Moo Cheong
Nuclear Materials Technology, Korea Atomic Energy Research Institute, ymcheong@kaeri.re.kr

1. Introduction

A guided wave method has been used for the long-range inspection of the pipe using longitudinal mode L(0,2) or torsional mode ((0,1) [1,2].

A shear horizontal (SH) wave mode has many advantages for a detection of cracks in the plate. The SH mode shows no mode conversion at the reflector as well as no dispersion characteristics. The SH mode in the plate is similar to the torsional mode in the pipe [3].

In order to generate the SH wave mode, electromagnetic ultrasonic transducers, such as the electromagnetic acoustic transducer (EMAT) or magnentostrictive sensor (MsS) has shown superior performance to the conventional piezoelectric transducer.

In this paper, a magnetostrictive sensor technique was used for generation and reception of the ultrasonic guided waves in a plate. The reflection characteristics of the SH mode from various artificial notches were investigated in the view point of the length, width, and depth of the notches.

2. Experimental methods and results

An Aluminum plate with a dimension of 1.2 m X 1.2 m and thickness of 0.6 mm thick was used. A notch with the width of 2 mm, length of 25 mm, depth of 2 m and a through wall notch with same dimension were fabricated by an EDM machining process.

The phase velocity and group velocity of the dispersion curves were determined for the Aluminum plate (thickness = 5 mm), as shown in Figs. 1 and 2.

The physical principle of the ultrasonic generation by a magnetostrictive sensor can be explained by the Joule-Wiedermann effect [4]. A nickel strip glued to the surface of the sample was magnetized along the longitudinal direction for magnetic bias and alternating current was applied to the coil for the alternating magnetic field. These two magnetizations combined together and results in a shear horizontal displacement.

In order to study the effect of angular characteristics a bar type magnetostrictive sensor was located from the 0 degree to 90 degree with a 15 degree interval, shown in Fig. 3.

The energy reflected from the through wall notch was measured with different incident angle. Fig. 4 shows a little variation in reflection energy for the case of 64 kHz. However, the energy increases drastically when the incident angle approaches to 90 degree for the case of 64 kHz.

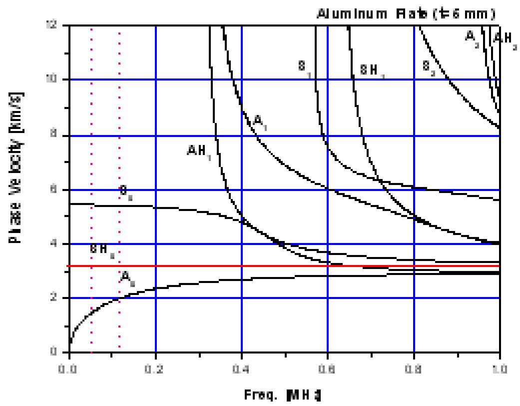

Fig.1. Phase velocity dispersion curve for SH modes in an aluminum plate with the thickness of 5 mm.

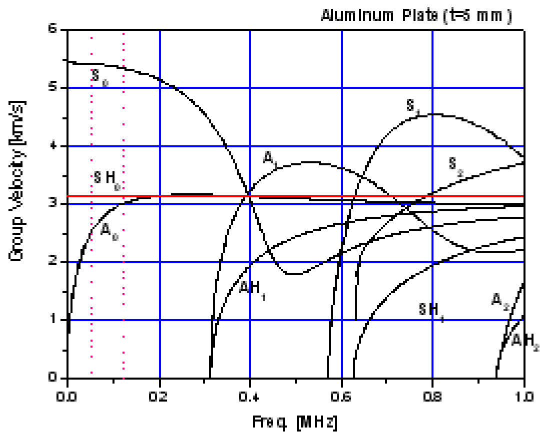

Fig. 2 Group velocity dispersion curve for SH modes in an aluminum plate with the thickness of 5 mm.

This fact can be correlated to the comparison of the wavelength and notch length. The wavelengths are calculated as 25 mm for the case of 128 kHz, and 50 mm for the case of 64 kHz. Because the notch length (50 mm) is almost same as the wavelength of 64 kHz, it can be explained that the reflection energy increase at the 64 kHz with the geometry of 90 degree.

Fig. 5 shows the reflection characteristics with variation of incident angle in the case of 64 kHz. The notch with 50% of wall thickness is less sensitive to the through-wall notch.

Therefore, when we applied the SH wave mode for the detection of notches, the sensitivity could be lowered in a certain case, even the displacement is perpendicular to the propagation direction. It should be considered the frequency, shape of the defect (wavelength to the length, width, depth), and reflection angle, etc.

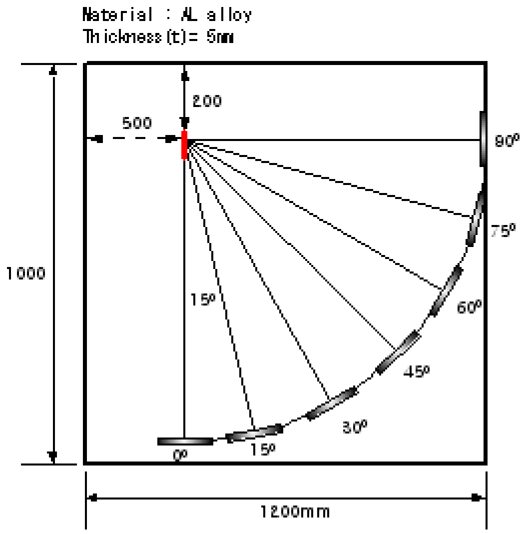

Fig.3 Configuration of guided wave inspection of artificial notches in aluminum plate (unit: mm).

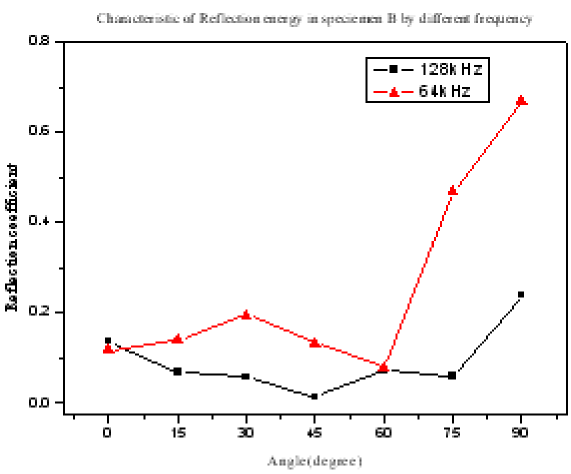

Fig.4 Characteristics of reflection energy in the aluminum plate. (unit: volt).

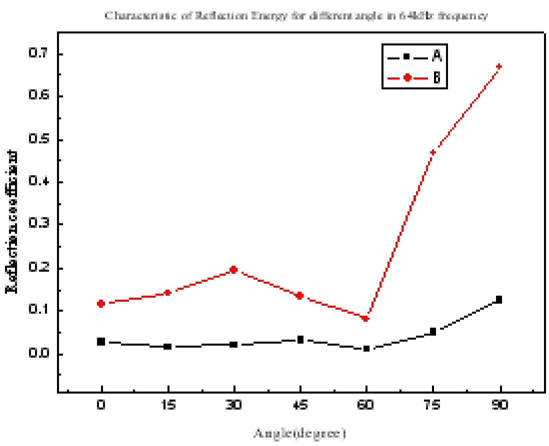

Fig.5 Characteristics of reflection energy for different angles with frequency of 64 kHz. (unit: volt).

3. Conclusion

The SH wave mode was generated in the aluminum plate by a magnetostrictve sensor. The reflection energy from the through-wall notch and 50% of wall thickness were measured with different incident angles and frequencies. The wavelength to the notch length as well as the width and depth should be considered to get the maximum response from the notch.

REFERENCES

[2] Y. M. Cheong, D. H. Lee, S. S. Kim and H. K. Jung, "Analysis of circumferential guided wave for axial crack detection in a feeder pipe", 11th APCNDT, Jeju island, Korea, (2003) .

[2] Y. M. Cheong, D. H. Lee and H. K. Jung, Ultrasonics, Vol. 42, pp.883-888 (2004).

[3] J. L. Rose, Ultrasonic waves in solid media, pp. 241, Cambridge University Press (1999).

[4] N. S. Tzannes, IEEE Trans. Sonics & Ultrasnonics, Su-13, pp.33-41 (1966).