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Non-contact Thickness Measurement of a Non-magnetic Plate using EMAT

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1. Introduction

EMAT (Electro-Magnetic Acoustic Transducer) is a non-contact transducer that generates and detects the ultrasonic waves in electrically conductive materials. As the coupling between the EMAT and the sample is electromagnetic, they are relatively insensitive to a misalignment when compared to the contact methods. EMATs can be designed to generate various wave modes such as a Rayleigh wave, a Lamb wave and a shear horizontal (SH) wave. [1]

EMAT uses a combination of static and dynamic magnetic fields to convert electrical energy into acoustic energy. The static magnetic field is induced by a permanent magnet and the dynamic magnetic field is produced by an electrical coil. By the Lorentz force (F) principle between the static magnetic field (B) and the eddy current (J) from the dynamic magnetic field, EMAT can generate and detect ultrasound in electrically conductive materials.

The sample that will be examined within this paper is a non-magnetic material such as aluminum in order to optimize the parameters of a Lorenz Force type EMAT for an effective inspection of a material loss or a defect detection for a nuclear component under a high temperature and radiation environment.

2. Design of the EMAT

The dynamic magnetic field (B_d) which pulses the surface of a sample is induced from the current that runs through the flat printed coil. When the induced eddy current (J) is as shown in Figure 1, the Lorenz force (F) in the presence of a static magnetic field (B) can be given by [2]

$$\vec{F} = \vec{J} \times \vec{B} \qquad (1)$$

This shear Lorenz force propagates the shear horizontal waves into the target material through a surface movement.

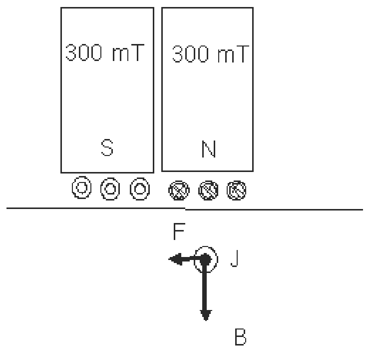

Figure 1 Principle of the SH wave generation

3. EMAT Measurement of the aluminum plates

EMAT transducer consists of a permanent magnet with 300 mT and a printed coil with 8 kW pulse if the maximum out power is required. Tests were performed with two kinds of aluminum samples using a high power ultrasonic gated amplifier system RPR-4000.

A typical EMAT waveform is shown in Figure 2, representing a shear wave wall thickness measurement of a 7.6 mm aluminum plate with a high power ultrasonic system.

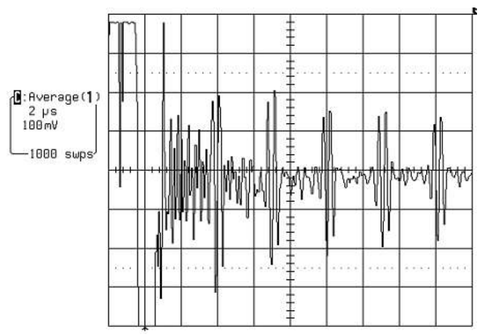

Figure 2 Typical waveform of 4.9mm thick Al plate

For a comparison, Figure 3 shows the waveform obtained from the same material except for a 0.25 mm thickness of an aluminum strip.

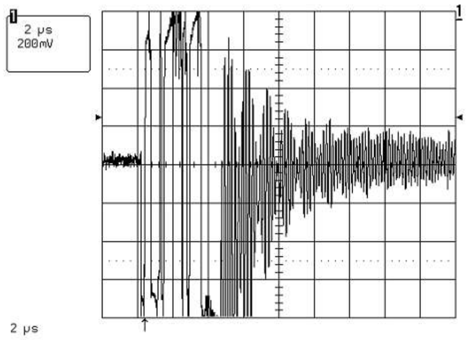

Figure 3 Waveform from 0.25mm thick Al strip

The EMAT can produce a SH wave without a mode conversion. The SH waves provide a greater resolution than a longitudinal wave due to a shorter wavelength, and can thus measure a thinner minimum wall at a given frequency. [3]

4. CONCLUSIONS

It is possible to conclude that the Lorenz Force type EMAT is a useful inspection tool for an aluminum plate and strip for a thickness measurement. The minimal thickness under a normal test condition is about 0.2 mm. The EMAT saves an inspection time because no couplant is required for scanning across a sample.

Acknowledgements

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References

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