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Sensitivity of a Torsional Guided Wave Signal using a Magnetostrctive Transducer Technique

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1. Introduction

The presence of damage or defects in pipes or tubes is one of the major problems in nuclear power plants. However, in many cases, it is difficult to inspect all of them through conventional ultrasonic methods, because of their geometrical complexity and inaccessibility. Particularly when a pipe is buried in the ground, it is difficult to detect a defect until the defect grows even to the point of leakage. To prevent the leakage of a buried pipe, several NDE (Nondestructive Evaluation) methods are proposed, and the guided wave method can be a promising technique [1].

One promising feature of the magnetostrictive sensor technique is that the wave patterns are relatively clear and simple compared to a conventional piezoelectric ultrasonic transducer. If we can characterize the evolution of the defect signals, it can be a promising tool for the structural health monitoring of pipes for a long period as well as the identification of flaws [2].

Among various vibration modes, the torsional guided wave T(0,1) mode has many advantages, such as no dispersion, no radial displacement, and a low attenuation.

In this paper, we analyzed the amplitude of the wave reflected from several reflectors in a low alloy carbon steel piping. The torsional guided waves were generated and received by a coil and a DC magnetized nickel strip. The signal amplitude from various reflectors is compared with two different sensor techniques, one by a variation of DC bias and the other by a remnant magnetic bias technique.

2. Experimental setup

DC bias magnetization along the circumference of a tube is required for the generation of a torsional vibration mode, T(0,1). A circumferential magnetization of a magnetostrictive strip can generally be achieved by moving a permanent magnet along the circumference. Practically, however, this is not easy for a tube with a small diameter. Coils 1 and 2 shown in Fig. 1 use remnant magnetization through the revolving of a permanent magnet. Another method to generate a circumferential magnetization is applying a DC current along the axial direction. A magnetic bend is fabricated to make a circumferential magnetization.

Fig. 1 shows an experimental setup for the magnetostrictive guided wave examination. Two coils with remnant magnetization are located at 500 mm from the left end of the pipe and 300 mm from the right end. The total length of the pipe is 3 m and the thickness is 7.0 mm. Another coil for a pitch-catch and a magnetic bend for DC bias is located at 500 mm from the right end. DC bias is controlled by a DC supply. A circumferential artificial notch with a depth of 40 % of wall thickness and the length of 25.4 mm is located 1 m from the right end.

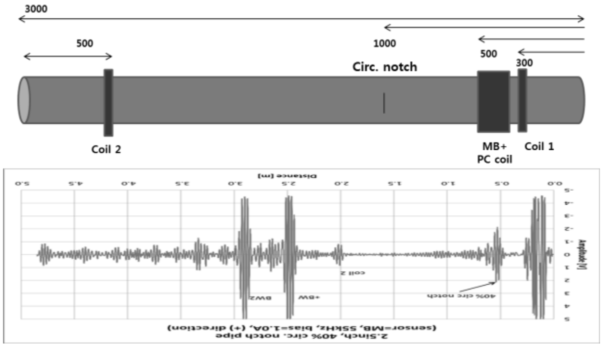

Fig. 1. Schematic experimental setup for magnetostrictive guided wave examination. Coil 1 is located at 300 mm from the right end; coil 2 500 mm from the left end; and MB(Magnetic Bend)+ PC(Pitch Catch) coil, is at 500 mm from the right end.

The typical wave pattern acquired from the magnetostrictive guided wave method is shown in Fig. 2. The signals from a 40% circumferential notch, coil 2, and BW (Back Wall) are clearly shown in Fig. 2.

When coil 1 is used for a pulse-echo transducer, some of the acoustic energy propagates in the negative direction, which is marked as "-BW" in Fig. 2.

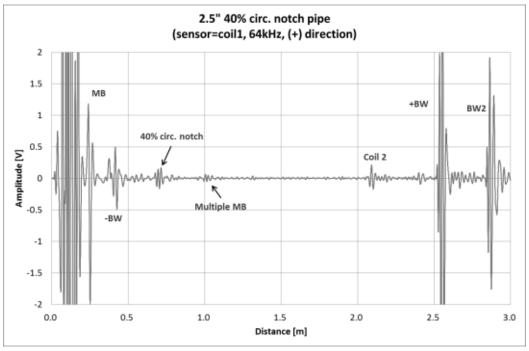

Fig. 2. Schematic drawing on the mode converted reflection at the end of a pipe.

3. Results and Discussion

When we take a signal from BW, the signal amplitude increases as the DC bias increases until 0.4 A and saturated even the bias increases up to 1.0 A, as shown in Fig. 3. It is commonly accepted that the optimized DC bias is around 0.4 A for this bias coil and the experimental setup.

Fig. 4 shows a plot of signal amplitude vs. DC bias. The signal is from a 40% circumferential notch at +0.68 m from the magnetic bend + PC(Pitch Catch) coil. When we take a relatively small amplitude such as a 40% circumferential notch, the signal amplitude increases as the DC bias increases until 1.2 A.

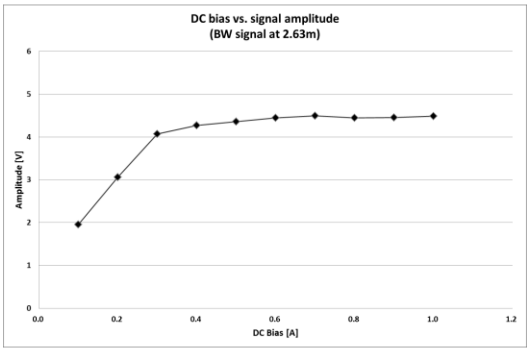

Fig. 3. Plot of signal amplitude vs. DC bias. The signal is from the BW(Back Wall) at +2.63 m from the magnetic bend+ PC coil.

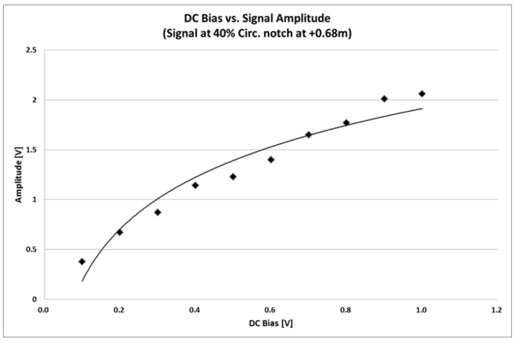

Fig. 4. Plot of signal amplitude vs. DC bias. The signal is from the 40% circumferential notch at +0.68 m from the magnetic bend+ PC coil.

4. Conclusions

The amplitude of a magnetostrictive guided wave signal was analyzed to optimize the DC bias magnetization. The signal amplitude from various reflectors was compared with two different sensor techniques, one through the variation of DC bias and the other using a remnant magnetic bias technique.

When we take a signal from the BW, the signal amplitude increases to a certain level, and saturates as the DC bias increases. The optimized DC bias is around 0.4 A for this the experimental setup and bias coil.

REFERENCES

[1] Technical Report, “Development of Aging Management Standard for Buried Piping”, KHNP, 2011.

[2] Kwun, H. And Kim, S. Y., G. M. Light, “The magnetostrictive sensor technology for long range guided wave testing and monitoring of structure”, Mater. Eval. 61:80-84, 2003.