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Monitoring of Defects in a Pipe Weld by a Comparison of Magnetostrictive Guided Wave Signals

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1. Introduction

Long-range guided wave method has been used in various industrial applications because of many advantages compared to the conventional ultrasonic examination. Basically this method is applied to structures with simple geometry, because there are many unwanted signals included in the acquired data, such as signals from welds, pipe supports, branch connections, reducers, etc. Unfortunately the defect is mostly founded in the weld regions and the defect signals overlapped to the geometry signals[1]. The method can be applied to the structural health monitoring to solve the problems[2].

One of the methods to generate and receive the guided waves is using the magnetostrictive sensors. The magenetostrictive strip sensors can be glued on the pipe surface permanently, and the signals can be acquired periodically. An advantage of a magnetostrictive strip transducer for a long-range guided wave inspection is that the wave patterns are clear and simple when compared to a conventional piezoelectric ultrasonic transducer. The method can be useful to monitor the variation of the signals accurately and can related to the generation and growth of the defects[3-6].

In this study a computer program for an accurate comparison and subtraction of guided wave signals were developed. The program contains an algorithm for calibration with the flight time and phases of ultrasonic signals in the time domain. Once the reference signals were acquired at the beginning of the monitoring, the signals can be compared to the reference. The signals due to the geometry can be eliminated clearly and an evolution of defect in a pipe can be monitored accurately.

2. Experimental Methods and Results

The dimensions of a pipe used for the experiment are a length of 3 m, diameter of 9 mm, schedule No. of 80. The material for the pipe was SA 106Gr. B. In order to investigate the effect of weld, two pieces of pipe was welded. Fig. 1 shows the experimental setup for the study. A magnetostricive strip(Fe-Co-V alloy) was glued to the outer surface of the pipe and circumferentially magnetized by a rotating the magnet. The ultrasonic guided waves were generated by a couple of the coils wounded on the strip. The torsion vibration mode, T(0,1) mode, was generated and received by the magnetolstrictive sensors. The T(0,1) vibration mode has many advantages because it has no dispersion, no radial displacement, and a low attenuation coefficient.

Fig. 2 shows the reference signal from the weld of pipe. The weld signal was detected at the distance of 1.7m from the end of the pipe.

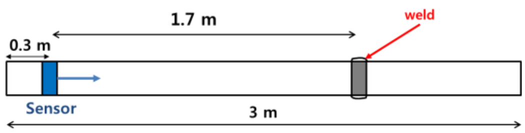

Fig. 1. Experimental geometry of the magnetostrictive sensor and the weld in the test pipe.

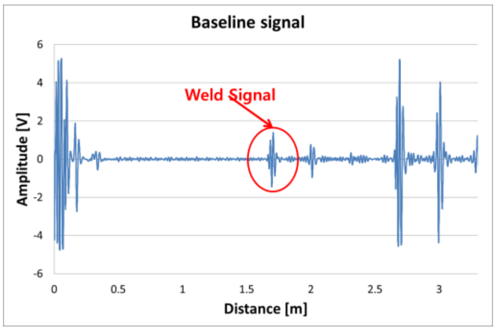

Fig. 2. Typical example of the reference signal of the weld region with no defect in a pipe.

A notch was fabricated in the weld and the acquired signal was compared to the reference signal. The acquired signal was matched in the time domain and reference signal was subtracted. In order to match the signals, an accurate calibration in phase and amplitude was performed to eliminate the environmental variation and the signals due to the geometry.

The signals were compared by generating a notch in the weld from 5 to 30 % depth of pipe thickness. As shown in the Fig. 3, the signal patterns were well matched in phase and amplitude. Fig. 4 shows the defect signals after calibration in phase and amplitude and subtracting the reference signal. The signal amplitude increases as the depth of notch increases. The defect signals can be distinguished clearly, even the depth of notch is 5% of the pipe wall thickness, which is equivalent to the 0.48% loss of CSA(cross sectional area) of the pipe.

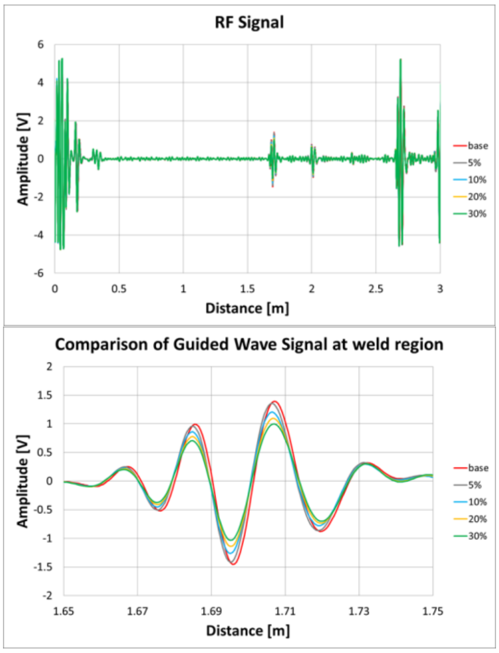

Fig. 3. Comparison of ultrasonic signals of various notches from 5 ~ 30 % of pipe wall thickness: RF signals overlapped (top) and magnified signals at the weld region with various depths of notches (bottom).

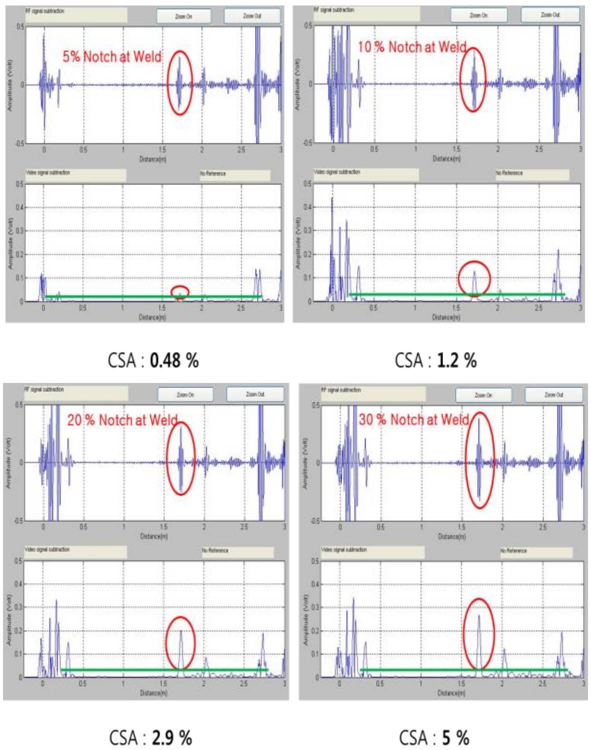

Fig. 4. Monitoring signals of various notches after subtracted the reference signal. The notches range from 5 to 30 % of pipe wall thickness, which are equivalent from 0.48 to 5% loss of CSA.

Table I: Conversion of the depth of pipe wall thickness and the loss of CSA(cross-sectional area) of the pipe.

Notch depth	Defect area(%)
5 %	0.48
10 %	1.2
20 %	2.9
30 %	5

3. Conclusions

In order to improve the detectability and solve the problems of the guided wave methods, a magnetostrictive guided wave sensor technique was proposed. Because the waveforms by the magnetostrictive sensors are quite clear and repeatable, it is possible to detect the defects at the weld regions or even monitor the small variations of the defects after a permanent installation of the magnetostrictive strip sensors.

In order to eliminate the signals from the geometry, such as weld, pipe support, branch connection, a computer algorithm and program were developed.

A notch with 1.5% of CSA of the pipe can be detected with increased accuracy. The guided wave monitoring technique developed in this study can be a promising tool for inspection of the pipe with limited accessibility, such as insulated or buried pipe.

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