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Application of a Magnetostrictive Guided wave Technique to Monitor the Evolution of Defect Signals.

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1. Introduction

There have been many attempts to apply the guided wave technique to the nuclear pipe or components. However, the guide wave technique is hard to apply to examine the nuclear pipe or components, because of limited accessibility due to the complex shape and located high radiation, and the pipe is not quite long enough to apply the guided wave method. Furthermore, an acquired guided wave signal cannot distinguish whether the inner or outer defect, or the geometrical features, such as pipe support, branch connection, reducer and etc.

An advantage of a magnetostrictive strip transducer for a long-range guided wave inspection is that wave patterns are clear and simple when compared to a conventional piezoelectric ultrasonic transducer. Therefore, if we can characterize the evolution of defect signals, it could be a promising tool for a structural health monitoring of pipes for a long period of time as well as an identification of flaw [1-2].

Of course, when evaluating a signal during a realistic field examination, it should be careful because of some spurious signals or false indications, such as signals due to a directionality, multiple reflections, mode conversion, geometrical reflections etc. Therefore, the different frequency components of the guided waves will travel at different speeds and the shape of the received signal will changed as it propagates along the pipe[3-4].

Once the magnetostrictive sensors are attached in the pipe permanently and the signal shape and phase can be compared to the signals before and after, we can monitor the evolution of the flow for the given period. The problem in the comparison of the guided wave signals is not exactly same condition before and after. The temperature difference results in the change of signal position in the time domain or the horizontal axis of distance. Also the distance of certain reference signals can be changed when we compare the signals before and after. If the examiner distracted the signal before and after, there are lots of residue signal components or a kind of noise results in the final signal shape in the time domain.

In order to reduce those residue components remained in time domain, we developed a software program to adjust the reference signals before and after. Once the reference signals after are adjusted to the reference signals before, it can be clearly distracted the signal components. The S/W also can display the converted video signal and the comparison of the video signals show superior signal characteristics, such as low noise components. In this study, the software are used to reduce background or noise, when we subtracting the signal before and after.

2. Methods and Results

The pipe outside diameter is 730mm, thickness is 7mm, length is 3m. Figure 1 is a schematic experimental setup for magnetostrictive guided wave examination. The ultrasonic wave was generated and received from the coil 1 with a Fe-Co-V magnetostrictive strip. The Fe-Co-V strip was glued to the outer surface of the pipe and circumferentially magnetized by a rotating the magnet. There are two circumferential notches 1 m and 1.8 m from the pipe end. Crack signals were compared and monitored from the 10% to 40% of wall thickness at the point of 1.8 m from the pipe end.

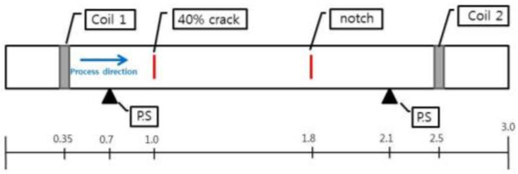

Fig. 1 Schematic experimental setup for magnetostrictive guided wave examination. Coil 1 is located at 350 mm from the left end(propagation direction is right).

Figure 2 shows the waveform of the notch before fabricating the notch in the pipe. Back-wall signal appeared point about 2.7m because wave start at coil 1.

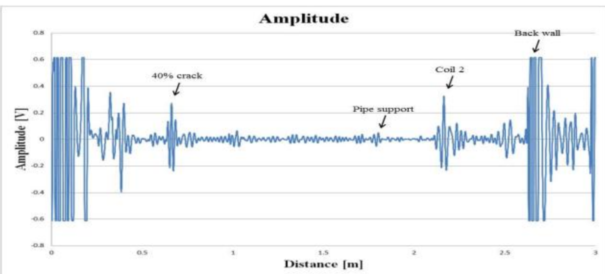

Fig. 2 Waveform appearing at each of condition in feeder pipe.

Theoretically, when we compare the ultrasonic signals for monitoring the evolution of the cracks, time and amplitude of reference signals such as pipe end signal in the time domain should be kept constant. However, the position of the ultrasonic waveform can be moved due to the temperature change and other surrounding environment. If the ultrasonic velocity is slightly altered, it is useless to subtracting the signals for defect monitoring.

Therefore, the time scale of both signals should be adjusted before subtracting the signals. We have developed a program to solve the problem to adjust the position and distance of the signal peaks(Subtracted Monitoring Program, National Instruments software, MATLAB).

Fig. 3 shows ultrasonic signal with no defect (top), ultrasonic signal with a defect (middle), and subtracted signals (bottom). In order to adjust the time scale of both signals, distance between the green line and red line calibrated as same distance. Through the distance calibration process, ultrasonic velocity and the signal distance are matched and the noise level can be minimized compared to the previous monitoring program.

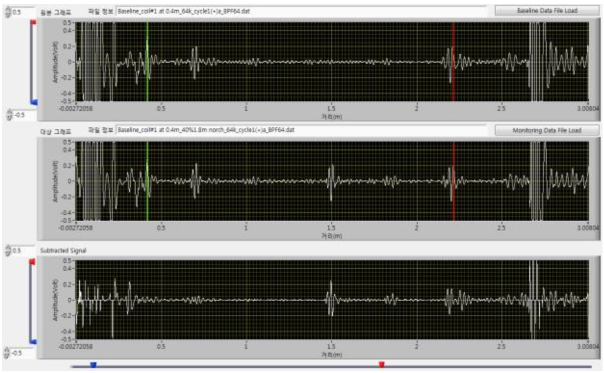

Fig. 3 ultrasonic signal with no defect (top), ultrasonic signal with a defect (middle), and subtracted signals (bottom)

Fig. 4 shows a comparison of subtracted signals by the previous program and newly developed program

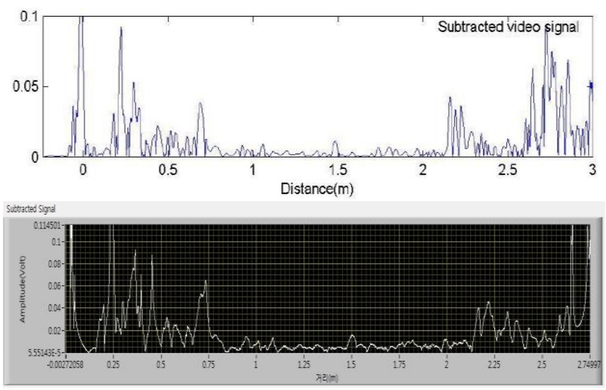

Fig. 4. Compared of subtracted guide wave signals by the previous program(up) and newly developed program(down).

The amplitude of the guided wave signal is depends on the size of the defect. Table 1 shows the conversion of notch depth to the CSA(Cross Sectional Area) of pipe

Table 1. Defect ratio to the CSA of pipe

Notch depth	Defect ratio (CSA%)
10%	0.76
20%	1.9
30%	3.7
40%	5.3

Generally minimum detectable defect size can be lowered to 2% of CSA. The signal from the notch with 10% of wall thickness was hard to be evaluated as a defect. The notch with depth of 10% of wall thickness converted to 0.76% of CSA. For the case of the notch with 20% of wall thickness or 1.9% of CSA could be distinguished as defect signal and the amplitude of the signal increases as the notch size increases, such as the case of notch with 30% of wall thickness.

3. Conclusions

We developed a program to subtract the guided wave signal. The program has a capability of adjusting the time scale and can minimize the noise level after subtraction. By applying the newly developed program, a notch with 2% of CSA can be detected with increased accuracy with noise reduction.

Accurate monitoring of the defect evolution can be accomplished with a permanently attached magnetostrctive sensor and periodical guided wave signal acquisition.

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