A Long-range Guided Wave Detection of a Hole Defect in a Carbon Steel Piping Mock-up using a Magnetostrictive Strip Sensor

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1. Introduction

A pipe leak takes place from corrosion, or erosion of nuclear power plant pipes under a high temperature and pressure. Accurate inspection of a corrosion and cracking in a pipe is required because a leak from primary pipes leads to a diffusion of a radioactive activity. A thinning of a pipe in a nuclear power plant is believed to be due to a flow-accelerated corrosion(FAC). FAC is affected by environmental factors such as the temperature, pressure, and pH. Thus, nondestructive techniques are required for a corrosion inspection of the pipes in a nuclear power plant[1]. All the vibration modes can be generated and received by using a magnetostrictive strip sensor technique. Torsional vibration modes, longitudinal vibration modes and flexural vibration modes can be possible by a combination of a direction of DC magnetic bias and an alternative magnetic field[2].

In order for a demonstration of an effectiveness of the long-range guided wave technique, a real scale piping mock-up with a length of 21 m with an elbow was manufactured. Dimension of this piping mock-up is diameter of 6 inch, and thickness of 11mm. An artificial hole was fabricated to locate a defect. A relationship between the amplitude and the cross section area of hole was obtained and a detectable limit of the hole defect was determined.

2. Fabrication of an Artificial Carbon Steel Mock-up Pipe and its Examination

Figure 1 shows a schematic design of a mock-up pipe. Holes with a range of diameter of 2 to 5 mm were fabricated at 9.5 m from the strip sensor, shown in Figure 2. A 49Fe-49Co-2V alloy strip sensor was bonded on the circumference of the mock-up pipe and magnetized along the circumferential direction for a DC bias magnetization. A torsional vibration mode, T(0,1) was generated by the strip sensor with a coil with alternating current. The signal was analyzed at both frequency of 32, 64 kHz.

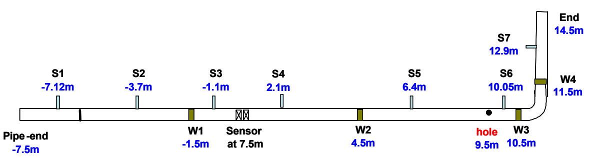

Figure 1. A schematic drawing of a carbon steel piping mock-up.

Figure 2. A Hole with a diameter of 5 mm fabricated in a mock-up pipe.

3. Results and Discussion

Figure 3 shows a signal obtained from the 5mm diameter hole is detected at 9.5m. Signals from a weld and an elbow are also shown at 10.5, 11m, respectively.

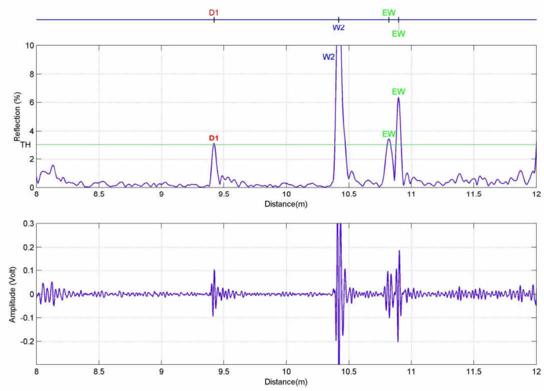

Figure 3. The signal obtained from a hole with a diameter of 5 mm in a piping mock-up.

Figure 4 shows a comparison of the amplitude due to a different size of a hole in the piping mock-up. As the diameter of a hole increases, the signal amplitude increases.

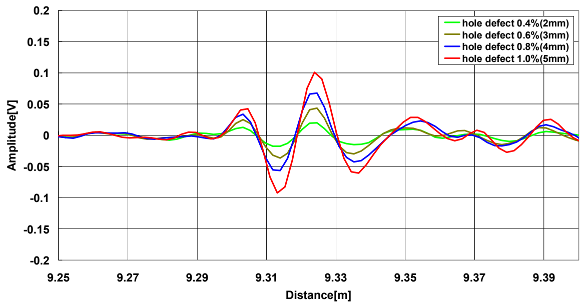

Figure 4. Signals from a various sizes of holes in a piping mock-up.

Figure 5 shows the relationship between the amplitude and cross section area of hole defects. As cross section area of hole defects increases, the amplitude from hole defects increases on the whole linearly with respect to the cross section area of hole defects. Detectable limit for hole defects was about 0.4% with respect to cross section area of hole defect.

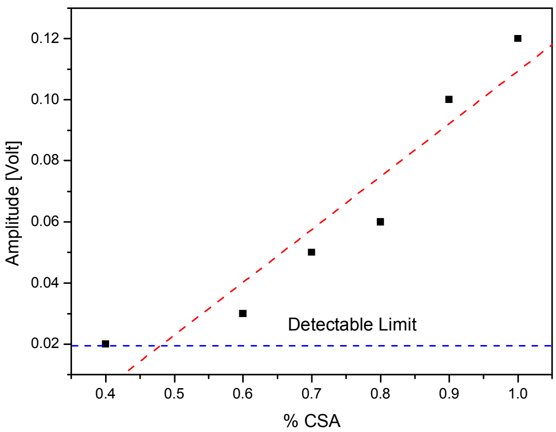

Figure 5. The amplitude vs cross section area (CSA) of hole defects in a piping mock-up.

4. Conclusion

A torsional guided wave signal from a various size of holes were obtained and analyzed using a Fe-Co-V alloy strip sensor at a frequency of 64kHz. As the cross section area(CSA) of hole defect increases, the signal amplitude increases linearly. Detectable limit for the hole defect was estimated as about 0.4% of CSA.

REFERENCES

[1] Most, "Development of Advanced Ultrasonic Wave Application Technology for Real Time Evaluation of Nuclear Pipe Corrosion under high Temperature and Pressure in Nuclear Power Plant", Busan National University, 2004.

[2] Yong-Moo Cheong, "Flaw Detection in Pipe by Magnetostrictive Guided Wave Technique," KAERI/TR-2927/2005, 2005.