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Application of pipe thinning caused FAC measurement technology using magnetostrictive strip guided ultrasonic non-destructive inspection

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1. Introduction & Objectives

- In the secondary system of a nuclear power plant, pipe thinning due to flow accelerated corrosion (FAC) caused a rupture accident, resulting in economic loss and human injury.
- the pipeline of the nuclear power plant is not only structurally complicated, but it is located in the high radioactivity area and covered with heat-insulating materials, so it is difficult to apply conventional pulse-echo ultrasonic nondestructive inspection technology.
- For the inspection of such pipes, the guided ultrasonic method is widely used. Currently, the commercially available guided ultrasonic wave method for pipeline inspection includes an array-type piezoelectric ceramic method and a magnetostrictive technique.
- As an advantage of guided ultrasonic inspection technology using the magnetostrictive method, scanning is not required, and since ultrasonic waves are little attenuation, a mostly volumetric coverage of long-distance inspection is possible
- In this study, after conducting a demonstration test of pipe thinning using the FAC facility, various thinning-related signals were evaluated using magnetostrictive strip guided ultrasonic technology, and analyzed in terms of electromagnetic properties of pipeline materials and magnetostrictive strip transducers.

2. Experimental

2.1 The principle of the magnetostrictive ultrasonic guided wave technique

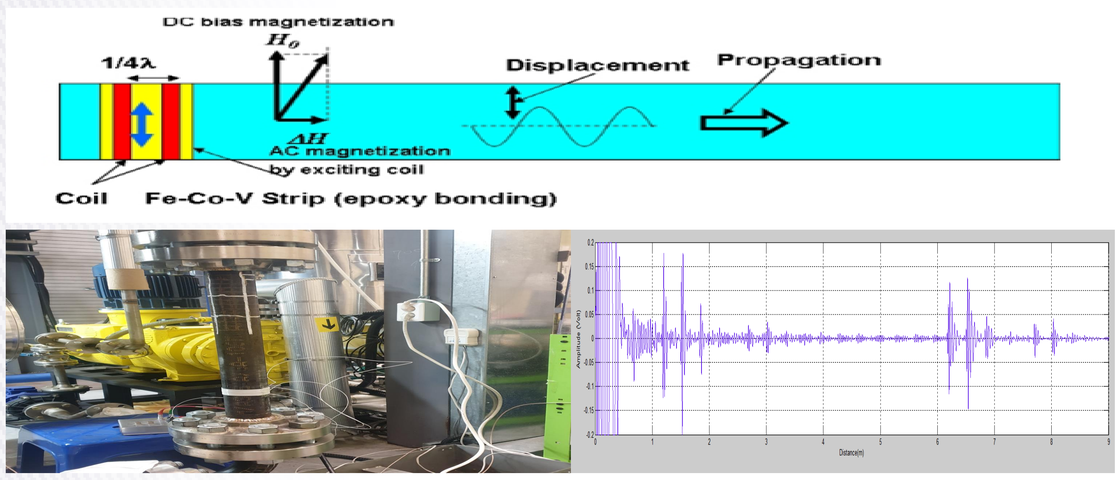

Fig. 1 Photo of widermann effect and installation of Magnetostrictive strip guided ultrasonic wave.

- Principle of magnetostrictive
  - ➢ By utilizing the relationship between the magnetic field and the deformation of the material, ultrasonic waves can be generated and a signal can be detected, so various applications are possible.
- Installaion of magnetostrictive strip and sample signal
  - ➢ By generating guided ultrasonic waves using these magnetostrictive strips, it is possible to monitor the thinning condition of the straight pipe line where flow accelerated corrosion during operation of the FAC facility.
  - ➢ It is possible to measure the location and amount of thinning by on-line monitoring the change of ultrasonic signals at regular intervals.

2.1 FAC test

FAC Test Conditions:
- **Test time : 33 days(800 hrs), Flow velocity : 1.5m/s**
- **DO < 5ppb, pH : 7, Pressure : 1.0Mpa, Temperature : 130°c**

Fig. 2 Photo of FAC demonstration test facility and various test conditions of this work

3. Results

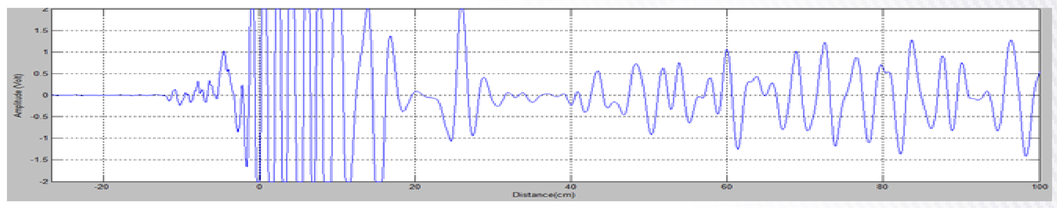

Fig. 3(a) Guided ultrasonic reception signal before FAC operation.

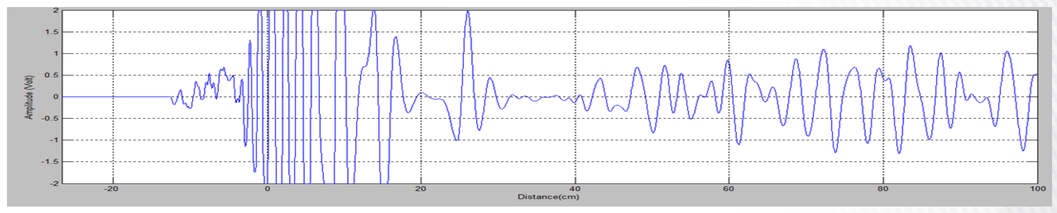

Fig. 3(b) Guided ultrasonic reception signal after FAC operation.

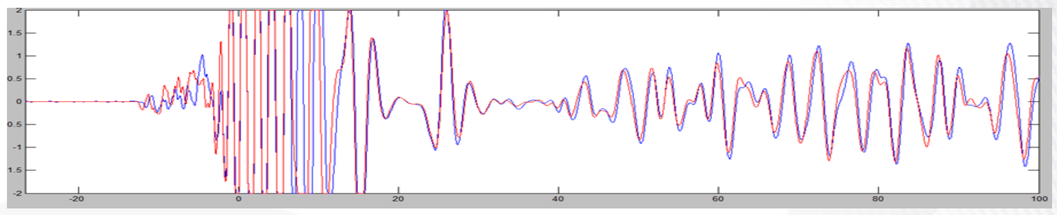

Fig. 3(c) Guided ultrasonic reception signal before and after FAC operation (before operation: blue, after FAC operation: red).

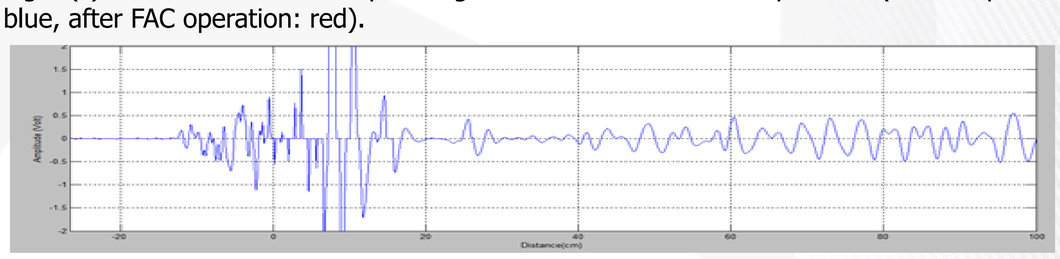

Fig. 3(d) Differences in the received signal of Guided ultrasonic waves before and after FAC operation.

• First, each signal was checked by referring to the structural characteristics of the pipe. To do this, we analyzed the waveform amplitude and phase of each ultrasonic signal and correlated it with the actually relevant signal.
•Fig. 3a shows the received ultrasonic wave signal of the straight pipe before FAC operation, and fig. 3b shows the received ultrasonic wave signal of the straight pipe after FAC operation.
•Fig. 3c shows the received signals of Fig. 3a and 3b superimposed. Since the guided ultrasonic signals before and after operation contain information on the integrity of the pipe at the time of measurement, the difference between these signals can show the change in the state of the pipe according to the FAC operation.
•Fig. 3d shows the difference in the signal before and after FAC operation, and the change in the pipe can be detected from this signal. The amplitude of the ultrasonic signal received was changed at the point where the corrosion defect occurs.
•Through this method, it is possible to diagnose whether the pipeline is damaged in advance and prevent to the pipeline breakage accident.

4. Conclusions

- In this paper, when applying magnetostrictive strip guided ultrasonic inspection technology to pipe thinning measurement, the most important matters are the selection of suitable vibration mode and selection of specific oscillation/reception sensors.
- The torsional vibration mode has many advantages because it has no mode conversion and dispersion, and is relatively lessaffected by the external matter.
- Using these advantages, a magnetostrictive strip guided ultrasonic sensor was installed in the pipe to enable constant monitoring through the periodic signal collection.
- By doing so, it was possible to estimate where the pipe thinning occurred.
- In the future, this technology will be able to contribute to the reduction of cost and time in improving the safety and quality control of facilities such as nuclear power plants.

5. Acknowledgement

This research was supported by Korea Atomic Energy Research Institute (KAERI) grant funded by the Korean government (Ministry of Science and ICT).

Nuclear Safety Technology Development Division