A Correlated Active Acoustic Leak Detection in a SFR Steam Generator

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1. Introduction

The methods of acoustic leak detection are active acoustic leak detection and passive acoustic leak detection. The methods for passive acoustic leak detection are already established [1], [2], [3], [4], but because our goal is development of passive acoustic leak detection for detecting a leakage range of small and micro leak rates, it is difficult detecting a leak in steam generator using this developed passive acoustic leak detection.

Thus the acoustic leak detection system is required to be able to detect wide range of water leaks. From this view point we need to develop an active acoustic leak detection technology to be able to detect intermediate leak rates.

2. Background

When water is leaked into sodium in a sodium-water steam generator, to react with sodium and water hydrogen gas is generated. Some portion of this hydrogen gas moves to the top of the steam generator, in the cover gas phase, but most of the hydrogen gas moved to the bottom sodium outlet of the steam generator as shown in Fig. 1.

In Fig. 1, the order from the upper photograph to the lower photograph is increasing Argon gas flow rate. The Argon gas injection rate is 9 ~30 cm^3/sec.

Fig. 1. Experimental work with injection of Argon gas for showing behavior properties of hydrogen gas when the sodium and water are reacted in a steam generator.

3. Experimental Works

The reactor is an Acryl column with a diameter of 200mm and height of 2000mm for showing behavior properties of hydrogen gas when the sodium and water are reacted in steam generator as shown in Fig. 2.

The circulation flow rate is 0.3~0.5m/sec, and the injection flow rate of Argon gas is 9 ~30cm^3/sec. The receiver of the ultrasonic sensor is 1MHz. The pulse instrument is a RITEC Square Wave Pulser SP801, and the measuring instrument is RITEC Broadband Receiver BR-640, and the signal filter is Krohn-Hite Model 3944.

Fig. 2. The correlated active acoustic leak detection system developing in KAERI.

4. Results and Discussion

4.1 Installation of ultrasonic sensor

The experiments for active acoustic leak detection technology was performed in CEA-Cadarache in France, and CRIEPI in Japan. That experiment analyzed with axial and radial installations of ultrasonic sensors as shown in Fig. 3. Recent work in CRIEPI was to install a sensor on wall of steam generator as a radial installation. The experimental scale was half size of real steam generator, and this experiment reported that it was possible to detect a leak rate below 1g/sec. However an experiment in KAERI with Argon gas injection in a water mock-up had a result to install a sensor on the wall of pipe at sodium outlet of steam generator.

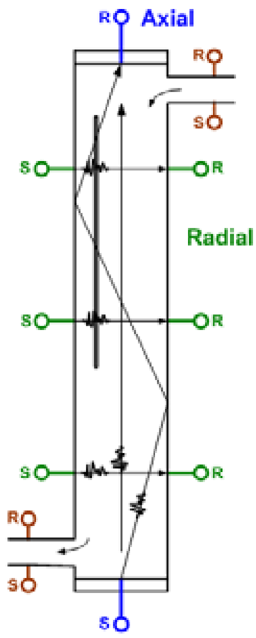

Fig. 3. Installation of ultrasonic sensors on wall of

steam generator, or at sodium outlet of steam generator.

This result is very useful to design of leak detection systems, because the sensor numbers are reduced, the installation is easy to compare with installation on the wall of steam generator.

4.2 Signal processing

As shown in Fig. 4, the ultrasonic sensors are installed at top location by the sodium inlet of a steam generator and bottom location at the sodium outlet of steam generator. The emitting signal transfer to the ultrasonic sensor has pulsing properties using RITEC Square Wave Pulser SP801, this emitting signal is divided into two pulse signals. The received signals, A(1) and A(2), from sensor at top location by the sodium inlet and sensor at the bottom location by the sodium outlet are compared, to say the signal A(1) is subtracted from the signal A(2). The final signal, A is A(1)-A(2). Before defining a leak accident it needs to define a threshold value.

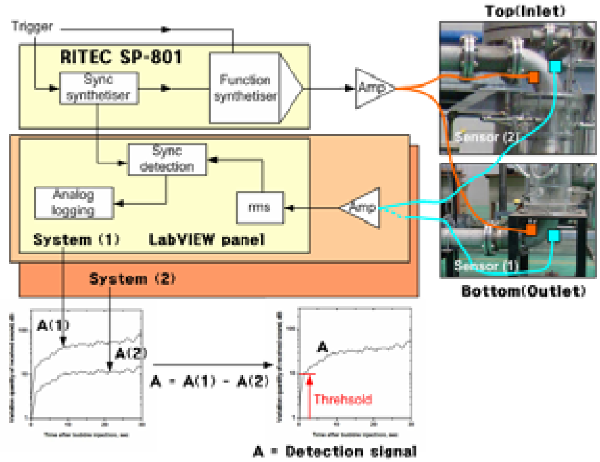

Fig. 4. Schematic drawing for signal processing.

4.3 Test results

The signals shown in Fig. 5 are impulse signal and received signal at bottom of reactor captured by LeCroy Model 9304A.

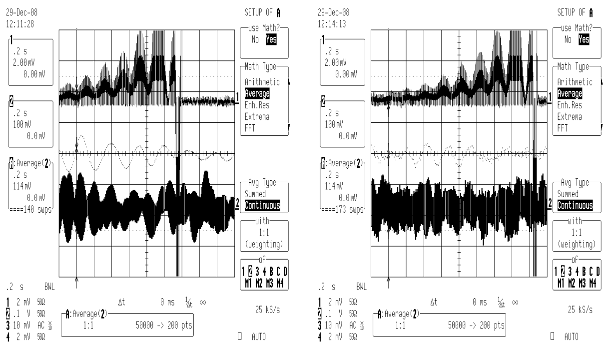

Fig. 5. Impulse signal and received signal at bottom of reactor.

The experimental conditions are with the Argon gas injection to water outlet and without Argon gas injection to water outlet. The left picture of Fig. 5 is without Argon gas injection to water outlet, and the right picture of Fig. 5 is with Argon gas injection to water outlet. In the picture the upper is impulse signal, and the lower is received signal of ultrasonic sensor.

The results show the difference in signal patterns between without Argon gas injection and with Argon gas injection in water outlet clearly.

5. Conclusion

The results established in our study are favorable for detecting leakages as intermediate leak rate.

To detect a leak as intermediate leak rate using correlated active acoustic leak detection developed in this study, the ultrasonic sensor it needs to install to sodium outlet of steam generator is K-600 SG.

The future works are to develop a signal processing method and proposed with methodologies of passive acoustic leak detection and active acoustic leak detection.

ACNOWLEDGEMENT

This study was performed under the Mid and Long-term Nuclear R&D Program sponsored by the Ministry of Science and Technology (MOST) of Korea.

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