Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 10-11, 2007

Development of the On-line Acoustic Leak Detection Tool for the SFR Steam Generator Protection

Tae-Joon Kim, Ji-Young Jeong, Jong-Man Kim, Byung-Ho Kim, Seong-O Kim
Korea Atomic Energy Research Institute, 150 Dukjin-dong, Yuseong-gu Daejeon 305-353, Korea
tjkim@kaeri.re.kr

1. Introduction

The successful detection of a water/steam into a sodium leak in the SFR SG (steam generator) at an early phase of a leak origin depends on the fast response and sensitivity of a leak detection system. [1] This intention of an acoustic leak detection system is stipulated by a key impossibility of a fast detecting of an intermediate leak by the present nominal systems such as the hydrogen meter.

Subject of this study is to introduce the detection performance of an on-line acoustic leak detection tool discriminated by a back-propagation neural network with a preprocessing of the 1/m Octave band analysis, and to introduce the status of an on-line development being developed with the acoustic leak detection tool(S/W) in KAERI. For a performance test, it was used with the acoustic signals for a sodium-water reaction from the injected steam into water experiments in KAERI, the acoustic signals injected from the water into the sodium obtained in IPPE, and the background noise of the PFR superheater.

2. Experiments

Measurements of the micro-leak noises in circulating sodium at a sodium temperature of 350~500^{o}C were executed in the IPPE facility and they have confirmed the prospects of a passive acoustic method for a micro-leak detection in an industrial steam generator in the KAERI facility. Another one, the sodium-water reaction experimental works of the steam injection were in a sodium test facility of KAERI. The container in the KAERI facility was constructed with stainless steel 304, and its sizes are height 2000mm, diameter 300mm and thickness of the wall 5mm. The injection in the KAERI experimental works was the steam at 87kg/cm^2, 300 ^{o}C and 0.37g/sec. The acoustic emission sensor was DECI-1000H, and the wave-guide was a diameter of 5mm and a length of 500mm. Here we tested the discrimination of acoustic leak detection by the back-propagation neural network after learning with the sodium-water reaction noises and the mixed noises of a sodium-water reaction signal and a background noise of the PFR S/H.

The signals to test the system as shown in Fig. 1 are prepared by mixing the signal to amplify and to attenuate the leak signals based on the amplitude of the background noise, the leak signal, and the background noises. This acoustic leak detection system as shown in Fig. 2, constructed with LabVIEW consists of the unit for preprocessing the signals and the neural network having the input of its feature vector by a pre-processing.

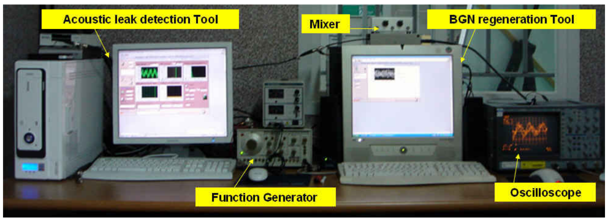

Figure 1. The On-line acoustic leak detection system developed in KAERI.

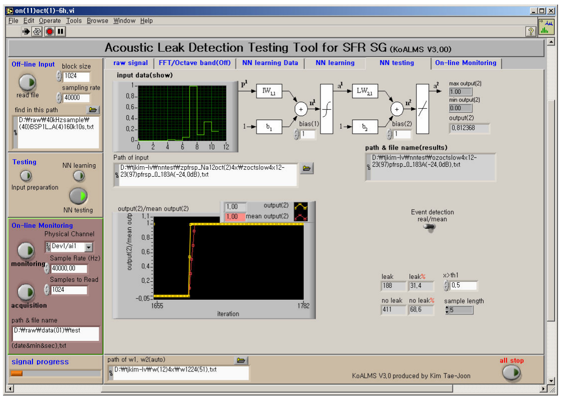

Figure 2. LabVIEW panel of the acoustic leak detection system developed in KAERI.

3. Results and Discussion

3.1 Analysis of the signals obtained by the steam injection into sodium

The typical analysis of the sodium-water reaction noise spectra resulting at a leak stage is presented in Fig. 3 by the FFT analysis. The FFT analysis were the KAERI sodium-water reaction signals mixed with the PFR S/H background noise (S/N; +12.1dB and -20.2dB), and the sodium-water reaction noises of the IPPE (Russia).

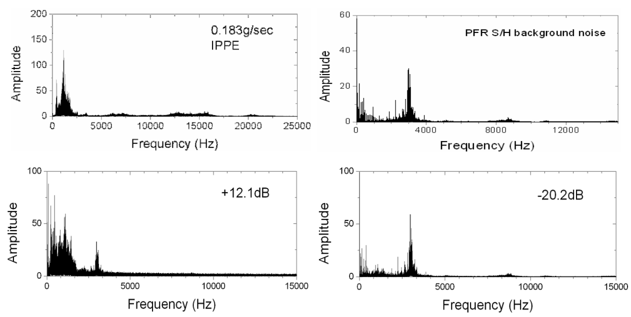

Figure 3. Typical FFT analysis results of the SWR acoustic noises mixed with PFR S/H background noise obtained by the KAERI SWR experiments for water into a sodium leak and by the IPPE.

In the steam injection to compare the bubbling frequency regime, the frequency by a bubbling was also around 1~2 kHz followed with the steam flow rates, according to the diameter of the micro nozzle under ~100kg/cm^2. The presence of smaller sized and larger hydrogen bubbles was insignificant.

3.2 Detection methodology for sodium-water reaction system

As described previously the acoustic leak detection methodology consists of the neural network and the preprocessing unit of the signals [2]. The preprocessing unit is also used for the 1/m Octave band analysis function, and its sampling rate of the input data of a preprocessing is 1024, and the selected frequency band is 0.5~2 kHz. After its preprocessing, it is again calculated for the input data of the feature vector for learning and testing the neural network, and then after an optimizing by learning of the weight values of the neural network and we monitor the raw leak signals using the optimized neural network to detect the leak state or no leak state based on the threshold condition to define the leak.

3.3 Performance of the acoustic leak detection tool

The performance of the developed acoustic leak detection methodology using the sodium-water reaction noises controlled with the attenuation of the IPPE sodium-water reaction signal and the KAERI sodium-water reaction signal against the background noise of the PFR S/H (super-heater) was shown to detect a leak up to -27dB according to the learning conditions of the neural network as shown in Fig. 4. One of the learning conditions was the background noise and the mixed noise with the background signal and controlled attenuation signal of the leak signal for the KAERI data and the IPPE data.

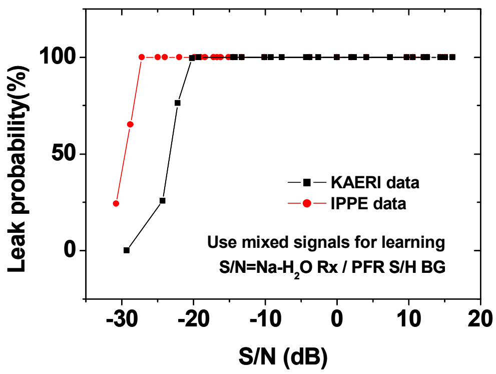

Figure 4. Leak probability tested by the developed acoustic leak detection tool.

3.4 The on-line tool test results using acoustic leak detection tool

The on-line tool performance of the developed acoustic leak detection methodology using the mixed signals with the PFR S/H background noise signal controlled with the attenuation of the KAERI sodium-water reaction signal is as shown in Fig. 5.

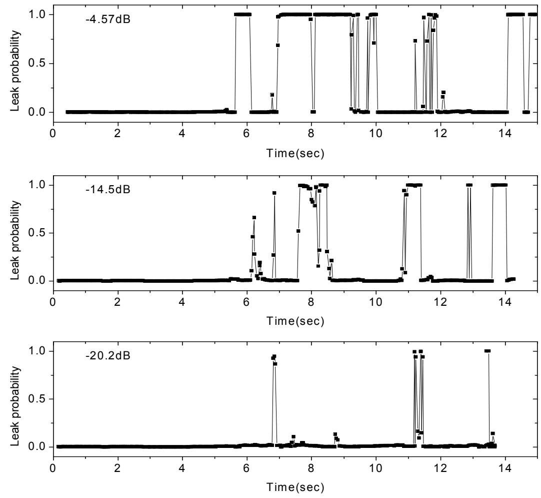

Figure 5. Leak probability tested by the developed on-line acoustic leak detection tool.

3. Conclusion

To protect the LMR SG from a damage of a tube bundle owing to the origin of secondary leaks it is necessary to detect a leak during its self-wastage up to the moment of an outflow diameter. The performance results by the developed acoustic leak detection methodology and the on-line tool could detect a leak up to -20dB, but the probability to detect a leak was missed according to the attenuation decrease. At present the system has no errors for detecting a leak up to -20dB, but in the future it must be absolutely assured that it has no error for detecting any leak.

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.

REFERENCES

[1] Tae-Joon Kim, Advantages of Acoustic Leak Detection System Development for LMR Steam Generators, Journal of the Korean Nuclear Society. Vol. 33, No. 4, pp. 423-440, 2001.
[2] Tae-Joon Kim, Comparison of the Signal Processing Methodologies for a Leak Detection of the LMR Steam Generator, Transaction of the Korean Nuclear Society Spring Meeting Chuncheon, Korea , May 25-26, 2006.