Effect of a Background Noise on the Acoustic Leak Detection Methodology for a SFR Steam Generator

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1. Introduction

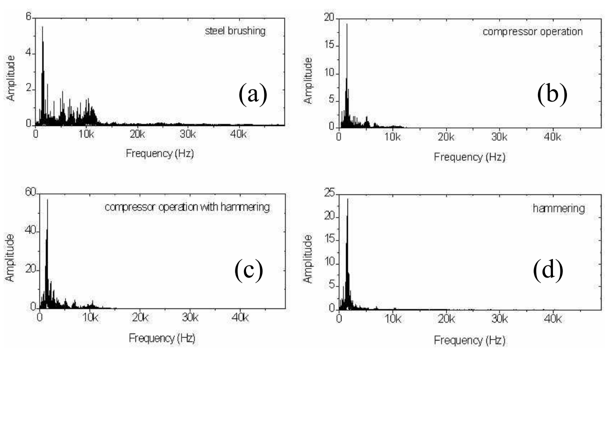
The protection of a water/steam leak into a sodium in the SFR SG at an early phase of a leak origin depends on a fast response and sensitivity of a leak detection system not to a response against the several kinds of noises. The subject in this study is to introduce a detection performance by using our developed acoustic leak detection methodology discriminated by a back-propagation neural network according to a preprocessing of the 1/6 Octave band analysis or 1/12 Octave band analysis and the x^n method defined by us.

It was used for the acoustic signals generated from the simulation works which are the noises of an artificial background such as a scratching, a hammering on a steel structure and so on. In a previous study, we showed that the performance of a LabVIEW tool embedded with the developed acoustic leak detection methodology detected the SWR leak signals [1], [2].

2. Experiments

For the experimental test of the previously developed acoustic leak detection methodology it necessary to prepare several kinds of signals like artificial background noises. The prepared typical background noises are the signals generated by the brushing of a steel surface with a wire brush (a), a compressor operation (b), a compressor operation with a hammering (c), a hammering on an equipped structure (d), a dropping of metallic object (e), a scratching on a metal surface with a metal thing (f), a high flow rate blow-out of a compressed air through any nozzle to room space (g), and a low flow rate blow-out of a compressed air through any nozzle to room space (h) as shown in Figure 1

To test the original raw signals as previously prepared signals and the mixed signals with the PFR S/H, an artificial background noise was prepared to mix two types of signals.



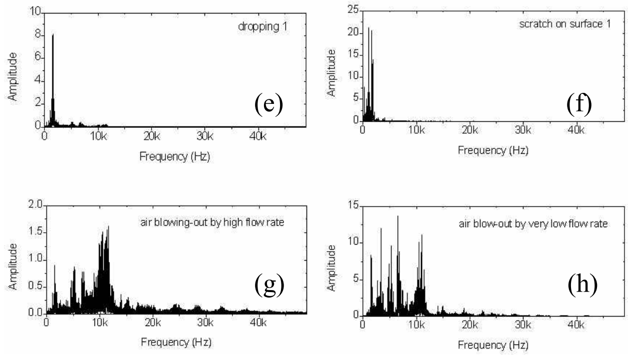


Figure 1. FFT spectrums for several kinds of signals

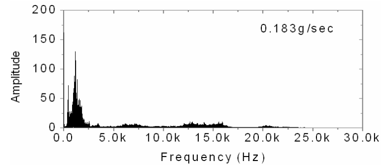


Figure 2. FFT spectrums for the SWR signal of the leak rate 0.183g/sec.

The SWR signal to test the performance of the acoustic leak detection methodology is shown in Figure 2, which is for the leak rate 0.183g/sec.

3. Results and Discussion

3.1 Investigation of the signal properties for testing the performance not to a response a sudden signal condition

The signals that are assumed to be able to be generated suddenly during the operation of a plant are produced as simulation signals. The frequency band of the acoustic leak detection methodology in this study is 0.47~1.6 kHz. The frequency band of the sodium-water reaction at a leak rate 0.183 g/s was in a boundary of its frequency band.

The artificial background noises are for developing the SWR detection methodology, like the signals generated as background noises where the signals are generated suddenly and mixed signals to mix two signals, and mixed signals with the PFR BGN and the artificial background noises.

As previous acoustic leak detection methodologies consist of a neural network and a preprocessing unit of the signals [1]. The preprocessing unit is used for the frequency band for the FFT power spectrum analysis and the 1/3 Octave band analysis function, and in some cases its processing unit was used for the 1/6 Octave band analysis and 1/12 Octave band analysis where the sampling rate of the input data of a preprocessing is 1024, and the selected frequency band is 0.47~1.6 kHz. If the frequency band of background noises is close and very similar with the frequency band the SWR signals, the detection methodology is used with the Octave band of a higher order as 1/12 Octave band compared with a lower order in the Octave band analysis.

After its preprocessing, it is again calculated for the input data of the feature vector for learning about and testing the neural network, and then after an optimization by a learning of the weight values of the neural network.

And we monitor the raw leak signals by using the optimized neural network to detect the leak state or no leak state based on the threshold condition to define a leak.

3.2 Performance of the acoustic leak detection system using test signals

A detection tool performance of the developed acoustic leak detection methodologies [1], [2] by using the sodium-water reaction noises controlled with the attenuation of the leak signal against the background noise of the PFR superheater was shown to detect a leak up to ~ -27dB according to the learning conditions of the neural network.

Using the tested detection methodology, when we test some background noises, the test results showed with no leak as in Table 1 and Table 2.

In Table 1, the input signal of a detection tool was used with the background noises without the background noise of the PFR S/H, and in Table 2 the input signals of a detection tool were used the mixed signals with the artificial background noises and the background noises of the PFR S/H.

Table 1. Leak probability tested by the developed acoustic leak detection methodology used the signals like as the background noises.

No.	Name of signal	No. of Leak event (%)	No. of no leak event (%)
1	The brushing on the steel surface	0(0)	1122(100)
2	The compressor operation	0(0)	1063(100)
3	The Ar gas injection into water	0(0)	1139(100)
4	The hammering	0(0)	1132(100)
5	The dropping of the metallic things	0(0)	1127(100)
6	The scratching on the metal surface with a metal thing	0(0)	1152(100)
7	The high flow rate blow-out of the compressed air through any nozzle to the room space	0(0)	1112(100)
8	The low flow rate bow-out of the compressed air through any nozzle to room space	0(0)	1165(100)
9	Mixed above signals	0(0)	1151(100)

Table 2. Leak probability tested by the developed acoustic leak detection methodology using the mixed signals with the artificial background noises and the background noise of the PFR S/H.

No.	Name of mixed signal with the PFR BGN	No. of Leak event (%)	No. of no leak event (%)
10	Brushing signal	0(0)	1189(100)
11	Compressor operation signal	0(0)	1189(100)
12	Ar gas injection signal	0(0)	1128(100)
13	Hammering signal	0(0)	1161(100)
14	Dropping signal	0(0)	1149(100)
15	Scratching signal	0(0)	1138(100)
16	High flow rate blow-out signal	0(0)	1160(100)
17	Low flow rate blow-out signal	0(0)	1114(100)
18	mixed with all above mixed signals	0(0)	1112(100)

The number of leak event or no leak event in Table 1 and Table 2, is the number of 1 word (1024 bytes) to analysis the signals measured by sensor for example.

4. Conclusion

To protect the SFR SG from damage from a tube bundle owing to the origin of secondary leaks it is necessary to detect a leak before it is developed to a leak status. When we tested the leak detection methodologies, it was beneficial to detect the event by using the 1/12 Octave band analysis, if the frequency band of the background noises and the frequency band of the SWR signals was very similar and very closed.

Up to this time our developed SWR detection tool with self-developed leak detection methodology was successful to define a leak or no leak, but we will continuously define and test the leak detection tool and the leak detection methodology.

ACNOWLEDGEMENT

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