Study on Sensor & Pre-Amp Diagnostic Technology in LPMS

Byong Su, Park, Man Gyun Na
Department of Nuclear Engineering, Chosun University,309 Pilmun-daero, Dong-gu, Gwangju, Korea
Corresponding author: mangyna@chosun.ac.kr

1. Introduction

Loose Parts Monitoring System(LPMS) is one of the NSSS Integrity Monitoring System(NIMS) [1]. The loose parts in the nuclear reactor causes nuclear fuel damage, control rod operation disorder and steam generator leakage as flowing with the fluid flow. The system acquires on-line monitoring impact sound induced by the loose parts to diagnose the state of the devices and analyzes its signal to detect their existence in the early stage of the breakdown and transmits the alarm signal to the main control section.

This paper presents the signal type and frequency response of steel ball impact test and background noise to determine the performance diagnosis and aging progress of LPMS sensors and preamplifiers based on the data obtained during planning precautions and current maintenance in Hanbit #1, 2. This study describes how to analyze their characteristics.

2. Methods and Results

2.1 Method using Simulated Shock Signal

This method diagnoses sensor performance by comparing the simulated shock signal waveform of a normal sensor with the simulated shock signal waveform of a degraded sensor.

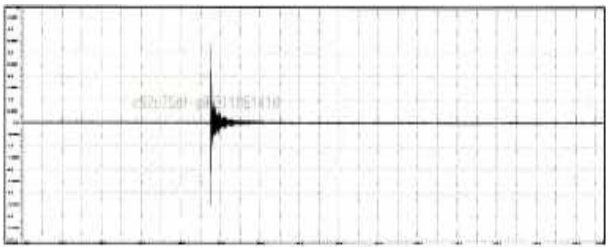

Fig. 1. Shock waveform of a normal sensor

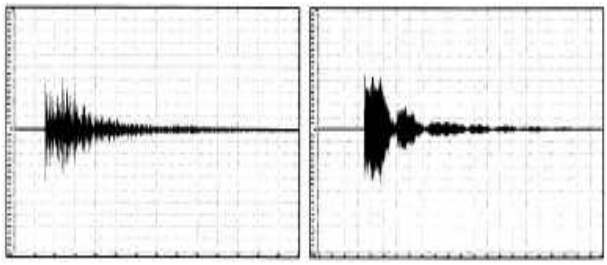

Fig. 2. Shock waveform of a degraded sensor

As shown in Fig. 1, the simulated shock signal waveforms of a normal sensor have tri-angular shapes and have a sharp rise time and a slow fall time. Degraded sensors, however, have a long signal fall time and are not properly attenuated

2.2 .Method using Background Noise

This method indirectly diagnoses the insulation condition of a sensor using a background noise.

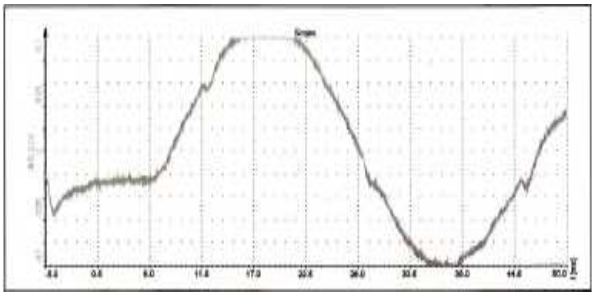

Fig. 3. Background noise of a degraded insulation sensor

Sensor insulation should be at least 10 Mega-ohms. However, as shown in Fig. 3, when the insulation is degraded, stray capacitance is formed between (+) and (-) poles, causing the output waveform of the sensor to shake.

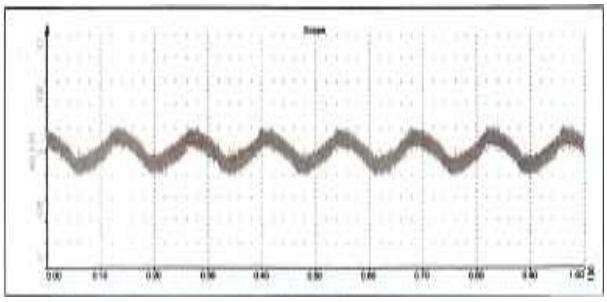

Fig. 4. Background noise of a degraded pre-amp

Background noise can be used to diagnose the performance of a pre-amplifier. If the background noise appears as a sine wave as shown in Fig. 4, the performance of the preamplifier is degraded.

2.3 Method using Background Noise Magnitude

The integrity of the sensor can be known by comparing the background noise signals of a normal sensor and a degraded sensor measured during normal operation.

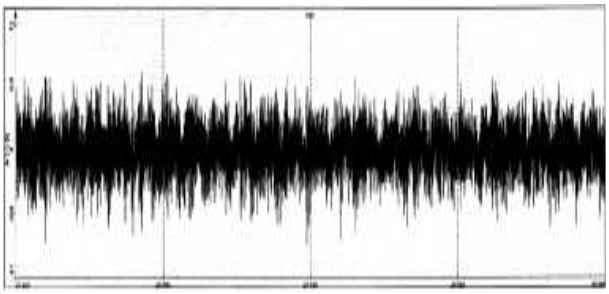

Fig. 5. Normal sensor's Background noise

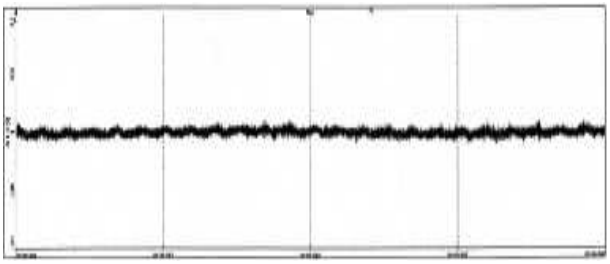

Fig. 6. Background noise of a degraded sensor

When the function of a sensor is degraded, its background noise is reduced by more than 1/2 than that of a normal sensor as shown in Fig. 6.

2.4 Method using Frequency Domain

This method diagnoses a sensor using frequency response characteristics according to the weight of steel balls of simulated shock signals acquired during Overhaul in NPPs

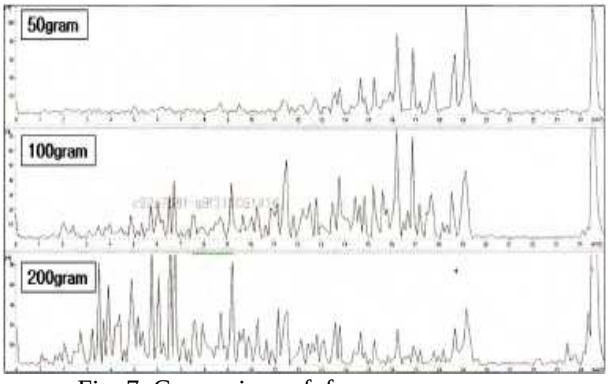

Fig. 7. Comparison of frequency response characteristics of simulated shock signals

The heavier the mass of steel balls, the more energy is distributed in the low frequency band, but the lower the sensor performance, the smaller the relationship between mass and energy distribution.

2.4 Method using Frequency Response Characteristics

This method diagnoses a sensor by comparing the background noise frequency response of a normal sensor with that of degraded sensor during normal operation.

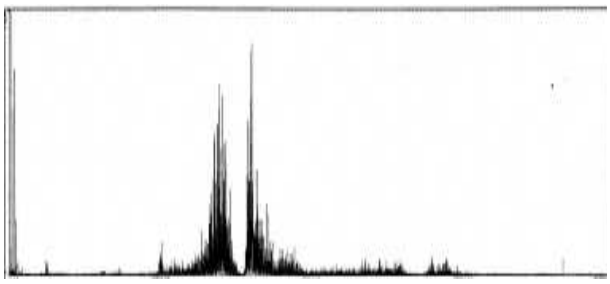

Fig. 8. Frequency response characteristics of a normal sensor

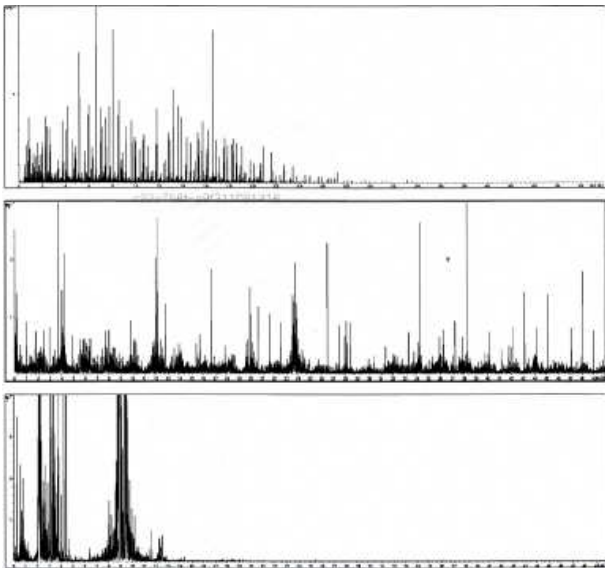

Fig. 9. Frequency response characteristics of a degraded Sensor

As for the background noise frequency response of the normal sensor, the frequency response of the resonance band is clearly shown in Fig. 8. However, when the function of the sensor is degraded, the energy is distributed in a similar magnitude in all frequency bands, or in the low frequency band than the resonance band (refer to Fig. 9).

3. Conclusion

Various methods were applied to analyze LPMS detector performance and aging progress. In the maintenance of the equipment, if the sensor replacement cycle is established and maintained in the same way as above, the equipment will be operated more stably. It will be helpful to improve the safety and reliability of NPPs.

REFERENCES

Reg. Guide 1.133 Loose-Part Detection Program for the Primary System of light-Water-Cooled Reactors.