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Study on the Fluid Leak Diagnosis for Steam Valve in Power Plant

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1. Introduction

This study aims to estimate the applicability of acoustic emission(AE) method for the internal fluid leak from the valves. In this study, 4 inch gate steam valve leak tests were performed in order to analyze AE properties when leaks arise in valve seat. As a result of leak test for valve seat in a secondary system of power plant, we conformed that leak sound level increased in proportion to the increase of leak rate, and leak rates were compared to simulated tests. The resulting plots of leak rate versus peak frequency and AE signal level were the primary basis for determining the feasibility of quantifying leak acoustically. Previously, the large amount of data attained also allowed a favorable investigation of the effects of different leak paths, leak rates, pressure differentials through simulated test. All results of application tests are compared with results of simulated test. From the application tests, it was suggested that the AE method for diagnosis of steam leak was applicable.

This paper presents quantitative measurements of fluid valve leak conditions by the analysis of AE parameter, FFT(fast fourier transform) and RMS(root mean square) level. Test apparatus were fabricated to accept a variety of leaking steam valves in order to determine what characteristics of AE signal change with leak conditions. The data for each valve were generated by varying the leak rate and recording the averaged RMS level versus time and frequency versus amplitude(FFT). Leak rates were varied by the valve differential pressure and valve size and leaking valves were observed in service. Most of the data analysis involved plotting the leak rate versus RMS level at a specific frequency to determine how well the two variables correlate in terms of accuracy, resolution, and repeatability.

2. Methods and Results

A test valve is 4 in. gate valve operated by motor and used to supply steam from reheater to condenser in secondary system of nuclear power plant. Tests were performed on a gate valve in operating using portable AE leak detector. The instrumentation was similar to that used in the other tests, except that a high-pass filter was used to eliminate the background noise caused by making vibrations being transmitted through the test system to the AE sensor. The differential pressures across the valve were in the range of 10 kg/cm^2.

Figure 1 is a plot of leak sound level(RMS level) versus leak rate for three types of the test valve in simulated test. Leak of approximately 60 ml/sec was obtained using the slit hole by inserting foreign objects in the test valve. Results of application tests are compared with results of simulated test of Figure 1. The sensor was attached to the valve flange by two types of method, direct contact method and indirect method using waveguide, and data were collected with the signal acquisition board. The data show that under the test conditions there is an adequate SN(signal-to-noise) ratio only upper frequencies of about 25 kHz and below frequencies of 530 kHz. This figure also shows a powerful increase of AE sound level with increasing leak rates in all size valves. Most of the investigation was restricted to low differential pressures across the valve because in practical applications higher differential pressures are difficult and costly to obtain.

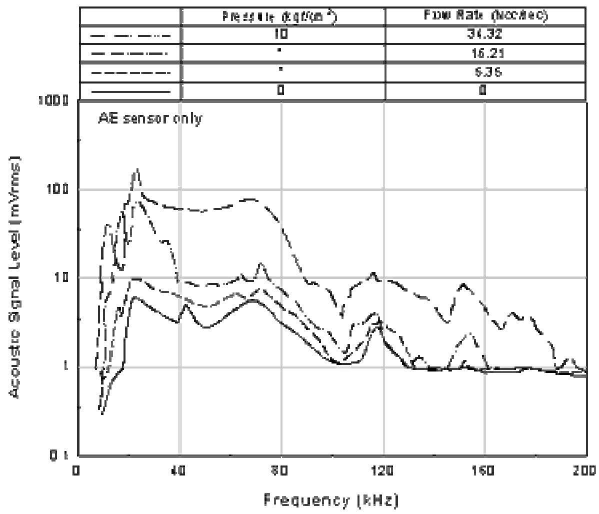

Figure 1. FFT spectrum of AE signal from leak through a 4 inch gate valve in simulated test

The data in Figure 1 is FFT spectrum of AE signal associated with leak through 4 inch gate valves in simulated test. There was found to be a somewhat linear correlation between the sound level of this signal and leak rate at constant pressure 10 kg/cm^2.

FFT analysis results on background noise during detecting leak for 4 inch gate valve are explained in Figure 2. AE rms level is 23 mVrms and represents peak component at both 30 kHz and 83 kHz. Especially, line spectrum of part had a large amplitude is the noise component in system itself. Figure 3 represents waveform and FFT analysis results graph. From this graph, acoustic signal shows a typical continuous type AE signal and it is confirmed that constant size amplitude is received to system continuously. And also, AE rms level is 32 mVrms and represents peak component at both 25 kHz and 70 kHz. As the test valve in site is 4 inch, gate and operated in condition of 10 kg/cm^2, it can be compared with results of simulated test results of the same condition showed in Figure 1.

Background noise spectrum represents 25 kHz and 70 kHz around and acoustic sound level increases according as leak rate increases in simulated test. But peak frequency component is the same value regardless of increase of acoustic sound level according to increase of leak rate. And we conformed that all test results have the same peak components in condition of leak rate of 0(BGN)~26.1 cc/sec. Small leaking of about 46.5 cc/min/inch was expected in site test valve and represented the same peak frequency components regardless of increase of acoustic sound level according to increase of leak rate.

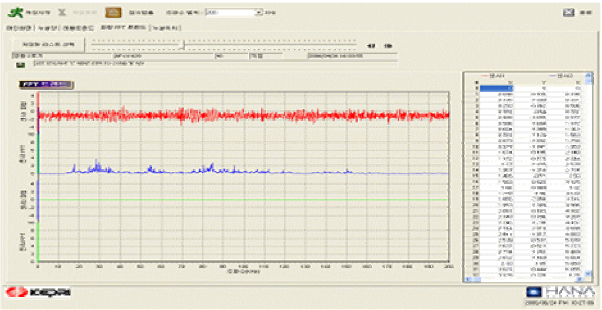

Figure 2. waveform and FFT analysis graph for background noise

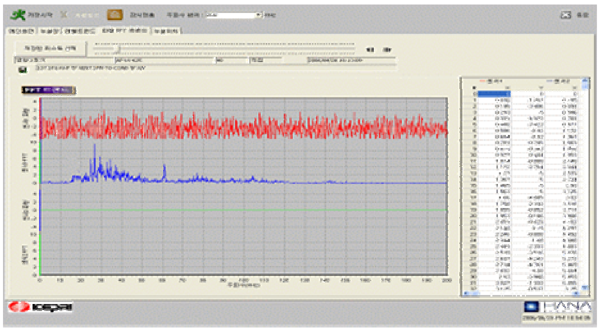

Figure 3. Waveform and FFT frequency analysis graph for leak signal

3. Conclusion

This paper presents quantitative measurements of fluid valve leak conditions by the analysis of AE parameter, FFT and RMS level. Test apparatus were fabricated to accept a variety of leaking steam valves in order to determine what characteristics of AE signal change with leak conditions. The data for each valve were generated by varying the leak rate and recording the averaged RMS(root mean square) level versus time and frequency versus amplitude(FFT). Leak rates were varied by the valve differential pressure and valve size and leaking valves were observed in service. Most of the data analysis involved plotting the leak rate versus RMS level at a specific frequency to determine how well the two variables correlate in terms of accuracy, resolution, and repeatability.

Background noise spectrum represents 25 kHz and 70 kHz around and acoustic sound level increases according as leak rate increases in simulated test in condition of 4 inch, steam gate valve and differential pressure 10 kg/cm^2. But peak frequency components represent the same value regardless of increase of acoustic sound level according to increase of leak rate.

REFERENCES

[1] A. A. Pollock and S. Y. S. Hsu, Leak Detection Using Acoustic Emission, J. of Acoustic Emission, Vol.1, No.4, p. 237-243, 1982.

[2] Y. B. Drobot, V. V. Lupanos and V. V. Bilibin, Study of Acoustic Emission When Water Leaks out into the Atmosphere Through a Small Hole, UDC620, p.297-303, 1981.

[3] Douglas E. MacDonald, Application Guide for Check Valves in Nuclear Power Plants, Final Report, NP-5479, Revison 1, Nuclear Maintenance Applications Center, 1993.

[4] Morse, P. M. and K. U. Ingard, Theoretical Acoustics, McGraw Hill, 1968.

[5] M. N. Hsu and S. C. Hardy, Experiments in Acoustic Emission Waveform Analysis for Characterization of AE Sources, Sensors and Structures, ASME, p. 85-106, 1978.