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Procedia Environmental Sciences 31 (2016) 426 – 431

Procedia Environmental Sciences

The Tenth International Conference on Waste Management and Technology (ICWMT)

Study on the underground storage of hazardous waste of the micro-seismic signal based on the S-transform time-frequency analysis

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Abstract

In the disposal of hazardous waste treatment technologies due to some solid waste is difficult, costly, often stored in deep underground storage. However, the impact of surrounding rock stability of these traits would waste rock fracture can cause leakage of waste, leading to environmental pollution. Micro-seismic safety monitoring technology is an effective means to solve this problem, but to the surrounding multi-source monitoring signal is a major difficulty for signal analysis. In this paper, the optimized ST (S Transform) is introduced into the analysis of micro-seismic signal, has high-quality time domain and frequency domain information to analyze various vibration signals. The method used in micro-seismic signal processing in the underground storage of hazardous waste. The result shows that the method can be used to automatically identify and analyze micro-seismic signals.

Peer-review under responsibility of Tsinghua University/ Basel Convention Regional Centre for Asia and the Pacific

Keywords: The underground storage of hazardous waste, Micro-seismic, Time-frequency analysis, S Transform

1. INTRODUCTIONS

Micro-seismic safety monitoring technology has been developed rapidly in the application of the underground storage of hazardous waste safety monitoring. However, the complex operating environment and the disturbance factor of the underground storage make a lot of vibration jamming signal(such as mechanical vibration and explosion etc.)of the scene can be easily collected by micro-seismic monitoring system. The diversity and the non-

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Peer-review under responsibility of Tsinghua University/ Basel Convention Regional Centre for Asia and the Pacific
doi:10.1016/j.proenv.2016.02.087

stationary randomness of signal determine the signal recognition and analysis must be very important but also extremely difficult, especially, how to identify the effective micro seismic signal, the signal of rock burst event, rapidly and effectively is particularly critical. The characteristics of all kinds of signals is the key point of the signal recognition, in order to study the micro seismic signal characteristics especially the local features of the non-stationary signal, the combined analysis of time domain and frequency domain is needed to obtain a more accurate description.

At present, the major time-frequency analysis method are Short-Time Fourier transform, wavelet transform and S-Transform, etc[1].The Short-time Fourier transform (STFT) use sliding window of a fixed length to intercept the signal and describe it's local feature by assumming the non-stationary signal is piecewise stationary, but according to the restriction of measurement uncertainty principle to the time-frequency resolution of window function[2],STFT need to consider the coordination of two factors of time and frequency resolution, which resulted in the limitations in its practical application. Similarly, wavelet transform is limited in its promotion since it is hard to find the wavelet function which can reflect the actual signal features in practice[3].S-Transform as a hybrid of short-time Fourier transform and wavelet transform has good effect on non-stationary signal analysis. It effectively overcomes the shortcoming that STFT cannot change the size of time window, and introduce multi-resolution analysis of wavelet transform, and also keep direct contact with the Fourier spectrum. Zhao-Atlas-Marks time-frequency analysis method is used to analysis and distinction between seismic and burst signals by Zhang Fan[4].The wavelet analysis has been used to select the suitable basic wavelet for micro seismic signal processing [5],and the authors have succeeded in drawing frequency-time-wavelet coefficient chart and time frequency spectrum. Xu Hongmei analyzed the noise signals of internal combustion engine by using S-Transform, got the regularities of distribution of signal energy and found how the frequency components changes with time[6].Hou Shujie improved the resolution of seismic data by using S –Transform[7].

In this paper, the generalized S-Transform which has achieved good application effect in geophysical exploration is introduced to the micro seismic signal time-frequency analysis, and one time window parameter optimized ST has been put forward which is suitable for micro seismic signal analysis. The technology is applied to a Mianyang of the underground storage micro-seismic monitoring issue, the paper summarizes the characteristics of different kinds of signals through the time-frequency analysis and privides an effective technical means for identifying rock burst signal.

2. METHOD AND PRINCIPLE

2.1. Basic theory of generalized S Transform

The S Transform can be regarded as an extension of wavelet transform, and the main advantages are: its resolution can change with the frequency, and it keeps a direct contact with the Fourier transform. These advantages indicate that the S-Transform is an effective method for analyzing non-stationary signals.

The S transform of signal can be expressed as follows：

$$S(\tau, f) = \int_{-\infty}^{\infty} h(t)\{\frac{|f|}{\sqrt{2\pi}} e^{\frac{-f^2(\tau-t)^2}{2}} e^{(-2\pi i f t)}\} dt \tag{1}$$

The Gaussian window can be adjusted according to the frequency, the Gaussian modulation function is given by：

$$\omega(\tau - t, f) = \frac{|f|}{\sqrt{2\pi}} e^{-\frac{t^2 f^2}{2}} \tag{2}$$

$$\int_{-\infty}^{\infty} \omega(\tau - t, f, p) d\tau = 1 \tag{3}$$

Generalized S-Transform reforms the Gaussian window function of S-Transform by introducing parameters P, so that it can flexibly adjust the variation trend of the Gauss window function with the frequency scale f according to the frequency distribution of non-stationary signal and the emphasis of time-frequency analysis. Not only can further