Analysis and Research on Microseismic Signal Characteristics and Energy Change of Working Face in Liyazhuang Mine

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Abstract. To provide a certain support for the prediction of the rockburst and setting of the threshold, the SOS microseismic monitoring system is used to remotely, real-time, dynamic and automatic monitoring of the seismic signal of the 2-228 working face of Liyazhuang coal mine. And the original signal of the microseismic is processed by the window Fourier transform, and the characteristics of the microseismic waveform and spectrum of different energy levels are analyzed. The results show that there are different characteristics of waveform and spectrum corresponding to signals at different energy levels. The high amplitude, low and centralized main frequency, long duration of signal, coda waves developing obviously than head wave and slow attenuation are the typical characteristics of strong mine earthquake. With the decrease of mine earthquake energy, the vibration attenuation rate gradually becomes faster, and the duration of the signal being shorter, the development of the head wave being obvious, the amplitude of velocity decreasing correspondingly, but the rate of amplitude decreasing gradually slows down, and the main frequency is gradually spread from concentration to diffusion, while the frequency distribution range is affected rarely. The research results can provide a scientific basis for setting the threshold of shock pressure prediction index and its risk prediction.

1. Introduction
China's coal mining continues to extend deep, resulting in high frequency and danger of dynamic disasters such as rockburst[1,2]. In order to quickly and efficiently predict and warn against ground pressure accidents, it is necessary to use monitoring and monitoring methods that are easy to operate and have strong anti-interference ability. At present, emerging geophysical methods such as infrared radiation, acoustic emission method, electromagnetic radiation method and microseism [3-7] have been rapidly developed and applied to the coal mining industry. Among them, microseisms are widely used in impact ground pressure due to their high sensitivity, safety and reliability and protruding mines [8,9].

In recent years, the application of microseismic monitoring technology in mines has developed rapidly and has great practical significance. Brady et al. [10] studied the characteristics of microseismic signals before and after rock bursts in hard rocks. Lei Wenjie [11] classified the four microseismic signals of blasting, coal wall collapse, roof and coal wall rupture according to the energy magnitude and
time sequence of microseismic events, and analyzed the characteristics and differences of each signal. Liu Haishun[12] performed time-domain and frequency-domain conversion analysis on microseismic signals based on fast Fourier transform, revealing differences in microseismic signals and spectral characteristics at different energy levels. Wei Sijiang[13] collected the microseismic signals when Yuejin Mine, Qianqiu Mine and Changcun Mine experienced ground pressure, performed fast Fourier transform on them, and analyzed the time domain waveforms and spectral characteristics of the microseismic signals. Yin Wanlei[14] analyzed the occurrence mechanism of rockburst from the perspective of space and time, and studied the relationship between key strata and mining speed on the frequency and energy of microseismic. Wang Lei et al.[15] constructed a microseismic monitoring system in 4106 material lane of Liangjia Coal Mine, analyzed the characteristics of microseismic activity during the excavation of soft rock roadway, and obtained that the moment magnitude of microseismic events was mainly concentrated at -2.770~0.589, and the high density area of microseismic events was 0~2 m. Therefore, based on the above analysis, this paper takes the 2-228 working face of Liyazhuang Coal Mine of Huozhou Coal and Electricity Group Company of Shanxi Province as the research object, and performs window Fourier transform on the detected microseismic original signals to analyze the microseismic spectrum of different energy levels, so as to provide certain support for the setting of the threshold value of the shock pressure prediction index.

2. Working Face Overview

2.1. Working Face Overview

The 2 # coal seam is currently being mined in the Liyazhuang Coal Mine of Huozhou Coal and Electricity Group Company of Shanxi Province. The monitored 2-228 working face belongs to the left flank working face of the 2 # coal seam second mining area. It is adjacent to the sixth mining area in the north and runs 600m long and 130m long. The maximum burial depth exceeds 600m. The roadway of the working face is a rectangular section, and it is supported by the anchor mesh beam and the anchor cable. Affected by factors such as plateau rock stress, mining concentrated stress, and gas, coal cannons are frequent during tunneling, and top and pinch drills are severe during drilling, and jetting often occurs. The top and bottom profiles of the working surface are shown in Table 1.

| Name         | Rock category       | Thickness / m | Lithology                   |
|--------------|---------------------|---------------|-----------------------------|
| Basic top    | Fine sandstone      | 2.1-3.8       | Calcareous cement           |
| Direct top   | Sandy mudstone      | 2.34-3.87     | Bedding development with fine coal grains |
| Pseudo-top   | Mudstone            | 0-0.34        | Weathered and fragile       |
| False top    | Siltstone           | 1.6-2.6       | Horizontal bedding          |
| Basic        | Fine sandstone      | 2.34-3.54     | Lumpy                       |

2.2. Characteristics of underground pressure

During the period of 2-228 working face from June 1 to June 30, 2011, there were three coming pressures, of which the first pressure came on June 5, and the second pressure came on June 13. Pressure, June 23rd for the third time. The working face has an average step pressure of 31m, and the average maximum working resistance of the support is 35MPa. It can be known that the working face has a large mine pressure, and stress concentration can easily cause dynamic phenomena such as impact ground pressure.

3. Microseismic measuring point arrangement

Li Yanzhuang Coal Mine introduced the SOS microseismic monitoring system to remotely, real-time, dynamically, and automatically monitor the mine's seismic signals including the impact ground pressure, and accurately calculate the time, energy and spatial coordinates of vibrations greater than 100J and the occurrence of impacted mines. The system consists of 1HZ-600HZ vibration recording performance, geophone measuring probe with embedded signal output template, central signal data receiver, digital information recorder for signal monitoring and analysis template, and central computer. The
microseismic original signal is transformed in time and frequency domain by window Fourier transform, and finally the energy magnitude and spectral characteristics of the microseismic signal are obtained.

The microseismic sensor measurement points should be evenly arranged near the working surface and form a mesh structure. The final measurement point arrangement plan is shown in Table 2. The DLM-2001 type detection probe is used now. The probe is fastened to the thread at the end of the anchor rod, in addition to the metal steel tube protective cover, the probe output cable should be connected through the underground explosion-proof junction box.

Table 2. Sensor measuring point arrangement scheme

| Numble | Position                                                                 | Coordinate |
|--------|--------------------------------------------------------------------------|------------|
| 1      | 6022 Air door to return air lane                                         | 37570606   |
| 2      | Substation in the middle of returning wind in Liucai District             | 37569564   |
| 3      | Substation No. 2 at 355 Return Wind Lane                                 | 37567261   |
| 4      | At the bottom of the main shaft return air lane                          | 37566700   |
| 5      | 2281 Pingxiang, the second wind in the second mining area                 | 37568281   |
| 6      | 2281 flat lane in the second mining area                                 | 37568599   |
| 7      | 2282 flat lane in the second mining area                                 | 37568699   |
| 8      | 2282 Pingxiang, the second wind in the second mining area                 | 37568455   |
| 9      | The bottom of the return wind down the mountain in the second mining area| 37568911   |
| 10     | At the wind return downhill alley in the second mining area              | 37567733   |
| 11     | Alleys with wind returning downhill in Sicai District                    | 37568230   |

4. Microseismic spectrum analysis at different energy levels

During the one-month period from June 1 to June 30, 2011, the mine's microseismic monitoring system recorded that the energy of microseismic events was concentrated between 102 and 105J. The microseismic signal generated each time will be received by multiple sensor measurement points. Due to the propagation distance of the vibration signal in the medium, the waveform and frequency band characteristics of the signals monitored by the sensor measurement points with different positions from the source are different. For space, only the waveform and spectrum characteristics of the signals received by the sensor points closest to the source are analyzed.

4.1. Waveform and spectral characteristics of microseismic energy above $10^4$J

On June 13, 2011, a vibration with an energy of $3.99\times10^4$J was detected. The source of the earthquake was closer to Channel 6. Some waveforms and spectrum diagrams of this channel are shown in Figure 1. From Fig. 1 (a), it can be known that for this energy level, the amplitude range of the vibration speed of the signal waveform is large, mainly between $0.6\times10^{-4}$ to $6.5\times10^{-4}$m / s, and the duration of the microseismic signal is 800. Between 2000ms. As can be seen from Figure 1 (b), the frequency band of microseismic signals is mainly between 0–200Hz, and the main frequency is 40–70Hz.
4.2. **Waveform and spectrum characteristics of microseisms with energy above 10^3 J**

On June 6th, a vibration with an energy of 1.05 × 10^3 J was monitored. The source of the earthquake was the closest to channel 6, and some waveforms and spectrum diagrams are shown in Figure 2. From Fig. 2 (a), it can be known that for this energy level, the amplitude range of the vibration speed of the signal waveform is large, mainly between 0.2 × 10^{-4} to 5.0 × 10^{-4} m/s. Short, in the range of 600 ~ 1800ms. It can be known from FIG. 2 (b) that the frequency distribution of the microseismic signal is between 0 and 160 Hz, and the main frequency is wide and the low frequency is obvious, between 10 and 75 Hz. In combination with downhole field production activities, microseismic signals with such waveform characteristics and vibration energy around 1000J are mostly caused by downhole firing.

4.3. **Waveform and spectrum characteristics of microseisms with energy above 10^2 J**

On June 10th, a vibration with an energy of 8.71 × 10^2 J was detected. The source of the earthquake was the closest to channel 6, and some waveforms and spectrum diagrams are shown in Figure 3. From Fig. 3 (a), it can be seen that the amplitude range of the vibration velocity of the seismic signal waveform of this energy level becomes smaller, mainly between 0.2 × 10^{-4} ~ 4.5 × 10^{-4} m/s, and the signal duration is 400 ~ 1200ms. Fast decay. It can be seen from Fig. 3 (b) that the frequency distribution of the microseismic signal is between 0 and 160 Hz. Relative to high-energy signals, the main frequency band of low-energy vibration is wider and the distribution is more dispersed, which is 15 ~ 80 Hz. In combination with downhole on-site production activities, vibrations with such waveforms and energy characteristics and positioning results above the goaf are mostly caused by roof fall.
4.4. Comparison of microseismic signal characteristics

Excluding the influence of the medium's propagation distance, the energy difference between the microseismic signals closest to the seismic source is generally reflected in the waveform shape and spectral characteristics of the signal, as shown in Table 3. As can be seen from Table 3, high amplitude, low main frequency and concentration, long signal duration, tail wave development compared with the first wave, and slow decay rate are typical characteristics of strong mine earthquakes; as the mine earthquake energy decreases, the vibration attenuation rate It gradually becomes faster, the duration of the signal becomes shorter, the development of the first wave begins to be obvious, and the speed amplitude decreases accordingly, but the rate of amplitude decrease gradually slows down, the main frequency gradually develops from concentration to diffusion, and the distribution range of the signal frequency has little effect.

According to the field observations of the coal mine, it is found that the energy and frequency of microseismic signals are generally greater than 105J and 220Hz, respectively. Therefore, many characteristics of microseismic signals with energy levels greater than 104J are the focus of further analysis.

Table 3. Microseismic signal characteristics at different energy levels

| Energy level / J | Duration / ms | Amplitude / (× 10-4m / s) | Decay rate | First wave development | Coda development | Frequency / Hz | Frequency distribution / Hz |
|-----------------|--------------|---------------------------|------------|------------------------|-----------------|---------------|-----------------------------|
| E≥104           | 800-2000     | 0.6-6.5                   | Slower     | Not obvious            | Obvious         | 40-70         | 0-200                       |
| E≥103           | 600-1800     | 0.2-5.0                   | Faster     | More obvious           | More obvious    | 10-75         | 0-160                       |
| E≥102           | 400-1200     | 0.2-4.5                   | Fast       | Obvious                | Not obvious     | 15-80         | 0-160                       |

5. Conclusion

(1) There are different characteristics of the waveform shape and frequency spectrum of the signal at different energy levels. As the energy of the mine earthquake decreases, the attenuation rate of the vibration gradually becomes faster, the duration of the signal becomes shorter, the development of the first wave begins to be apparent, the speed amplitude decreases accordingly, but the rate of amplitude decrease gradually slows down, and the main frequency gradually develops from concentration to diffusion. But the distribution range of the signal frequency has little effect.

(2) High amplitude, low main frequency and concentration, long signal duration, tail wave development compared with the first wave, and slow attenuation rate are typical characteristics of strong earthquakes, and many characteristics of microseismic signals with energy levels greater than 104J are ours. The focus of further analysis provides certain support for the setting of the prediction index of the ground pressure and its threshold.

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