ZESZYTY NAUKOWE POLITECHNIKI ŚLĄSKIEJ 2000
Seria: GÓRNICTWO z. 246 Nr kol. 1480

Dou LINMING, He XUEQIU, Wang ENYUAN, Gu DEZHONG
China University of Mining & Technology, Xuzhou, Jiangsu, P.R.China, 221008

EXPERIMENTAL RESEARCH ON THE ELECTROMAGNETIC EMISSION OF ROCK & COAL BURST FAILURE

Summary. The rock & coal can produce the electromagnetic emission (EME) phenomenon, which can be measured with the EME intensity and the pulse number, in the deforming and failing. The experimental research reveals that the EME intensity is generally under a certain value before the coal mass produces impulsive failure. However, the EME intensity sharply jumps when the impulsive failure happens. The pulse number goes up with the load increasing and the deformation and breakage developing. According this regularity, the dangerousness of rock & coal burst can be evaluated, forecasted and foretold.

BADANIA EMISJI ELEKTROMAGNETYCZNEJ ZWIĄZANEJ Z GWAŁTOWNYM ZNISZCZENIEM SKAŁ I WĘGLA

Streszczenie. Z deformacją i niszczeniem skał i węgla związane jest zjawisko emisji elektromagnetycznej, którego miarami są intensywność i liczba impulsów. Badania eksperymentalne wykazują, że intensywność emisji jest generalnie niższa od pewnego poziomu, a wzrasta bardzo szybko, gdy dochodzi do gwałtownego niszczenia. Liczba impulsów rośnie przy wzrastającym obciążeniu wywołującym deformacje i spękania. Zgodnie z tymi obserwacjami zagrożenie gwałtownego pękania skał i węgla może być ocenione i przewidziane.

The rock & coal burst is a dynamic phenomenon of underground pressure whose failure characteristic of being abrupt, fierce and tough constitutes a major threat to the mine safety, causing tremendous economic losses and casualties for coal mines. Especially with the mining depth increasing, the problem of rock & coal burst is becoming more and more outstanding. The mine administrations in China like Xuzhou, Beijing, Datong, Fushun, Beipiao, Yanzhou, Zaozhuang, Xinwen, etc, are all facing the problem of rock & coal burst threat.

The countries worldwide, such as Poland, Czech, Germany, the U.S., Canada, Russia, South Africa, France, Japan, etc, all pay extreme attention to the research into the dangerousness evaluation and control of rock & coal burst. And remarkable successes have been achieved, making the occurrence of rock & coal burst reduced to the lowest level.

The electromagnetic emission (EME) technique is a forward-developing global physical method. The rock EME gives off electromagnetic energy outward. The survey and research on the EME in the rock breaking initiates from the discovery of the electromagnetic abnormality before earthquake by the researchers in the field of earthquake. The former Soviet Union and China are the countries that started the research in this field rather early, with Japan and the U.S. having begun the research as well. In recent years the study on the EME effect in rock breaking has witnessed development both theoretically and practically, especially in the field of earthquake forecast. From the 90s on, He Xueqiu, Liu Mingju, Wang Enyuan, et al[1,2], of China University of Mining & Technology, have been carrying out the research on the characteristics and regularities of coal EME.

1. The EME signal in the deforming and breaking of rock & coal

The Experimental studies reveal that the EME will arise when the rock & coal deforms and breaks. The EME is the result of the deformation and breakage occurring when the non-homogeneous materials like coal, etc, are under load. And it is caused by the speed-shifting movement of the charged particles producing in the course of the charge transferring and the fracture expanding induced by heterogeneous speed-shifting deformation by the various parts of the coal mass.

Fig.1 shows the experimental result of some mine's raw coal. There were one of 67 EME events recorded in the figure where t(i) (i=1, 2, ···, 67) indicates the moment the events started being recorded and the velocity of the sample was 2MHz.

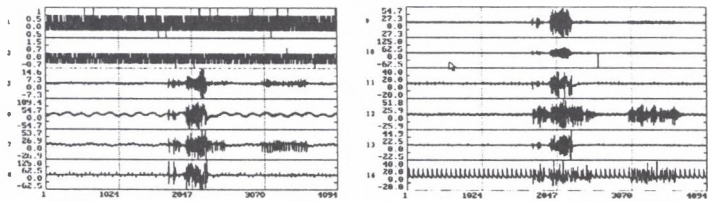
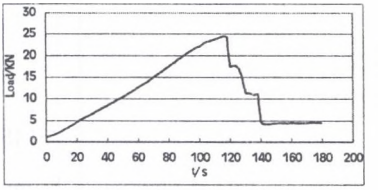


Fig.1. The EME experimental recorded result of some mine's raw coal

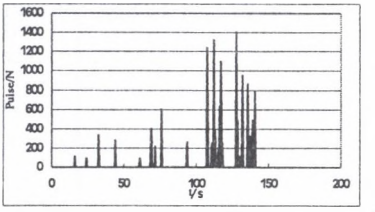
2. The experimental research on the rock & coal burst failure

The rock & coal samples under natural state, in the laboratory, were processed into standard test specimens to be used to perform uniaxial compression test in which the EME, generating in the deformation and breakage of the rock & coal, was measured at the same time. The highly precise, loading-rate-controllable and oil-pressure-adjustable MTS servo material tester was used to be the loading instrument.

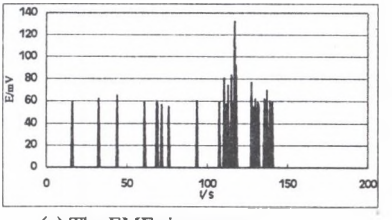
The experimental research result on the rock & coal samples is shown in Fig.2 and Fig.3 which indicate the load-time curve, the EME pulse number distribution and the EME intensity distribution of the samples of the coal and the sandstone respectively. The experimental research result reveals below.



(a) The load-time curve

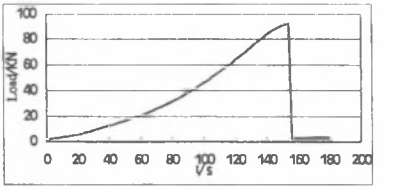


(b) The EME pulse number-time curve

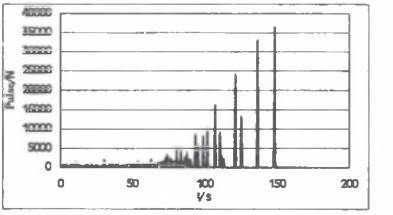


(c) The EME-time curve

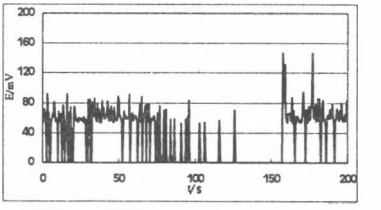
Fig.2. The experimental result of the coal samples



(a) The load-time curve



(b) The EME pulse number-time curve



(c) The EME-time curve

Fig.3. The experimental result of the sandstone samples

1. The rock & coal mass of different types can produce EME signals in the course of both the deformation and the breakage under the effect of load. The EME basically intensifies with the load growing and with the loading and the deforming rate increasing, in the deforming and breaking of the loaded coal mass.

2. The EME intensity, in the view of the experimental result of the coal deformation and failure, is generally under a certain value before the coal sample produces impulsive failure. However, it sharply jumps when the impulsive failure takes place. It averages 60mV or so before the impulsive failure while it reaches 130mV at the most after the impulsive failure.
3. The pulse number of the rock & coal EME can rise with the load going up and the deformation and breakage intensifying. The higher the load, the bigger the loading velocity, the tougher the deformation and breakage of the coal mass, and the stronger the EME signals.
4. The loaded coal mass is of Kaiser effect, shown in Fig.4.

3. The practical measurement result

Fig.5 shows the EME value of one measurement. Fig.6 shows the EME variation regularity before and after the occurrence of some mine's rock & coal burst. From the figure, when the EME extent exceeds a certain limit, the rock & coal burst is possible to come. Moreover, its occurrence regularity is that within the time before the occurrence, the EME value is comparatively high, afterwards, it is comparatively low. The experimental research and practical measurements both indicate that the rock & coal burst can be perfectly forecasted with the EME method.

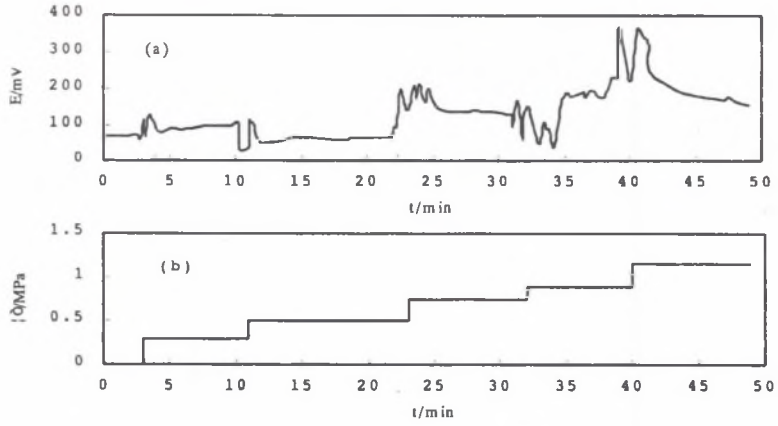
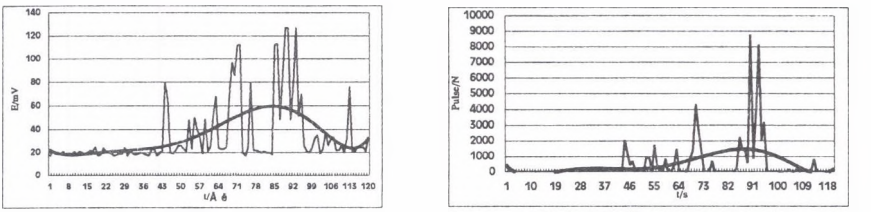


Fig.4. The relationship between the rock & coal EME and the load



1) the EME extent 2) the EME pulse number

Fig.5. The EME value of one measurement

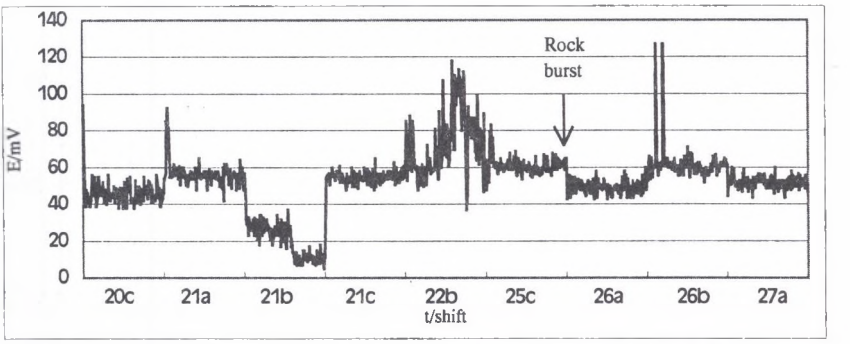


Fig.6. The EME variation regularity before and after the occurrence of the rock & coal burst

4. The main conclusions

The above-mentioned research on the EME generating in the deformation and impulsive failure of the rock & coal reveals below.

1) The EME signal can produce in both the deformation and the failure of the rock & coal under load.
2) The EME intensity is generally under a certain value before the rock & coal mass produces impulsive failure. And it sharply jumps when the rock & coal burst happens. According to this regularity, the rock & coal impulsive failure and burst can be forecasted.
3) The EME pulse number, when the rock & coal mass deforms and fails, can rise with load going up and the deformation and breakage intensifying, from which the deformation and failure intensity of the rock & coal mass can be assessed.
4) The practical measurements have also shown the EME regularity of the rock & coal impulsive failure.

5) Consequently, the EME is a very effective global physical method to forecast and foretell the rock & coal burst and appraisse its dangerousness.

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Recenzent: prof. dr hab. inż., dr h. c. Bernard Drzęźla

Podsumowanie

Problem zagrożenia sejsmicznego kopalń narasta wraz z pogłębiającą się eksploatacją górniczą. Jedną z metod przewidywania wstrząsów może polegać na badaniu emisji fal elektromagnetycznych (EME) towarzyszących procesowi niszczenia skał. W normalnych warunkach poziom EME odpowiada pewnej określonej wartości typowej dla danego rodzaju skał. W procesie nagłego pękania anizotropowych pokładów skalnych dochodzi do gwałtownych przemieszczeń cząstek obdarzonych ładunkiem elektrycznym, co wytwarza fale elektromagnetyczne.

W pracy przedstawiono wyniki eksperymentalnych badań EME dla węgla i piaskowca. Uzyskane rezultaty wskazują na potencjalną użyteczność tej metody w zastosowaniu do predykcji wstrząsów górniczych.