

Study on Test Method of Rock Acoustic Emission and Damage Evolution Characteristics Under Triaxial Compression

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Abstract

Aiming at the disadvantages of being unable to detect the comprehensive and reliable acoustic emission(AE) signals with acoustic emission detector installed outside the triaxial chamber, reasonable test method is realized with the AE detector installed inside the triaxial chamber based on the communication interface refitting of MTS815 rock mechanical test system. Based on reasonable test method, compression fracture AE tests of coal specimens are carried out under different confining pressure. Compared with uniaxial compression test, the primary fractures inside specimens are relatively compressed to close by confining pressure, the AE activities decrease in the stage of compaction; at the same time, the time that the AE counts and the energy reaching their highest values are both relatively lag behind the transient time of the macroscopic failure of coal specimens, it shows that confining pressure improves not only the peak strength, but also the bearing capacity. Based on AE characteristics of coal specimens under the triaxial compression, the evolution process of triaxial compression failure can be simplified into four stages as compaction and elasticity, plastic failure, failure and its development, plastic flow.

Keywords: coal; triaxial compression; acoustic emission; fracture

1. Introduction

Acoustic emission(AE) phenomenon is an important precursor information of rock compression fracture, it is of important theoretical and practical significance to deeply understand the mechanism of rock failure and preventing dynamic disasters such as coal bump, coal and gas outburst, rock burst by using AE monitoring technology^[1].

Previous experimental researches are mainly about AE characteristics under uniaxial compression^[2], because of experimental conditions and problems of AE signals transmission, Research results of AE tests under triaxial compression are relatively scarce^[3-4]. In the past test studies, AE detector were installed outside triaxial chamber under triaxial compression test^[5-6], according to the principle of vibration wave propagation, it is unable to detect comprehensive and reliable AE signals in this situation. Because most of underground rocks are under triaxial compression condition, therefore, researching AE characteristics of rock damage fracture under reasonable triaxial compression is of well practical guiding significance of preventing dynamic disas-

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ters and accidents by using AE monitoring technology.

In this paper, according to the characteristics of the MTS815 rock mechanical test system, developing the pressure plate used to instal the AE detector, and refitting the communication interface of rock mechanical test system, achieving the reasonable triaxial compression AE tests with the detector installed inside the triaxial chamber. On this basis, carrying out the AE tests under different confining pressure for 3# coal of XuChang mine, and analyzing AE characteristics of coal specimens fracture evolution under triaxial compression.

2. Disadvantages of AE test under triaxial compression with detector installed outside the triaxial chamber

When carring out AE tests under triaxial compression, if the detector is installed outside triaxial chamber, it's difficult to detect comprehensive and reliable AE signals, and the SNR is low, it basically has the following several reasons:

Many types of vibration wave produced in the process of specimens' compression, such as longitudinal wave, shear wave, and so on. Longitudinal wave can be transmitted in a variety of medium; but the shear wave could be unable to through the liquid and gas, it could be only spread through solid. The strong energy composition of vibration wave is shear wave which produced by internal crack extension. Therefore, when the detector is installed outside triaxial chamber, a large part of shear wave with strong energy would be blocked off, only a small part would propagate along the transition path through the pressure plate and triaxial outdoor walls.

When the detector is installed outside triaxial chamber, although longitudinal wave could be propagate in the hydraulic oil, the propagation distance increases

when through the hydraulic oil and triaxial outdoor wall. According to the spherical wave's diffusion effect and absorption effect, the bigger the wave propagation distance is, the greater the AE signal energy attenuation.

Because of the influence of the laboratory environmental noise, detector is suffered significant electromagnetic interference when it is installed outside triaxial chamber, the SNR is relatively low.

3. Reasonable AE test method under triaxial compression with detector installed inside the triaxial chamber

Aiming at the disadvantages of being unable to detect the comprehensive and reliable AE signals when detector is installed outside triaxial chamber, in order to implement test method with detector installed inside triaxial chamber, developing the new pressure plate which is used to place acoustic emission detector, and refitting the communication interface, as shown in Fig.1.

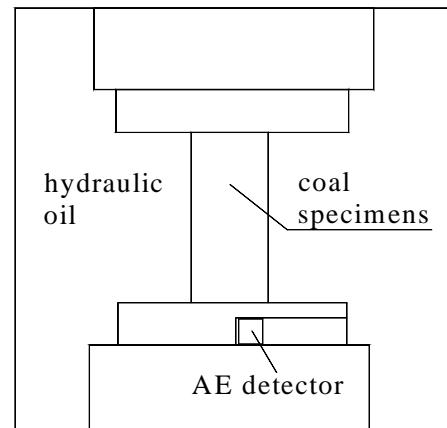


Fig.1 Schematic diagram of installing detector

Opening of the cavity was processed at the side of the pressure plate before the tests, and it was in the axis of the specimens below, the size of the cavity matched with the AE detector, the detec-

tor was placed in the cavity through the opening.

In order to make the shielding signal lines through from the communication channel, drilling a hole on the base which was connected with communication channel, in case of high pressure oil leakage, the hole was sealed with epoxy resin after the shielding signal lines through it, and connecting the shielding signal lines with AE detector pre-amplifier outside the triaxial chamber. In this way, reasonable AE tests were carried out with the AE detector installed inside the triaxial chamber.

4. Comparative analysis of AE tests under triaxial compression with detector respectively installed inside and outside the triaxial chamber

For the comparative analysis, coal specimens AE tests under triaxial compression were carried out with detector installed inside and outside the triaxial chamber in the situation of all other things being equal. Before the test, the built-in AE detector was placed inside the cavity of pressure plate, and the outer detector coupling in middle of the triaxial outdoor. For the better coupling of detector and triaxial chamber, grease was smeared between the two, then fixing the detector with waterproof tapes.

Analyzing the AE tests when detector respectively was installed inside and outside the triaxial chamber, AE characteristics of specimens are basically the same under different confining pressure, limited to the space, result of 3# coal from XuChang mine under the confining pressure of 3MPa is analyzed in this paper.

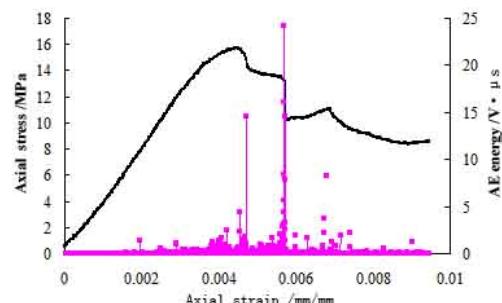
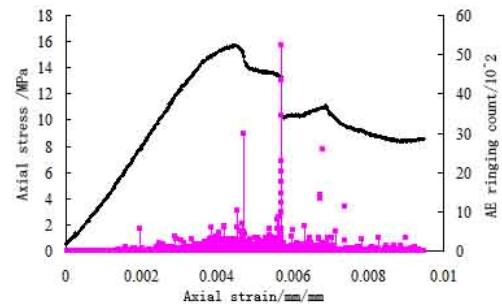
Contrast curves of specimens' AE ringing counts and energy when detector respectively was installed inside and outside the triaxial chamber are shown in Fig.2.

In the process of loading, specimens roughly have the same change rules, the difference is that the maximum ringing

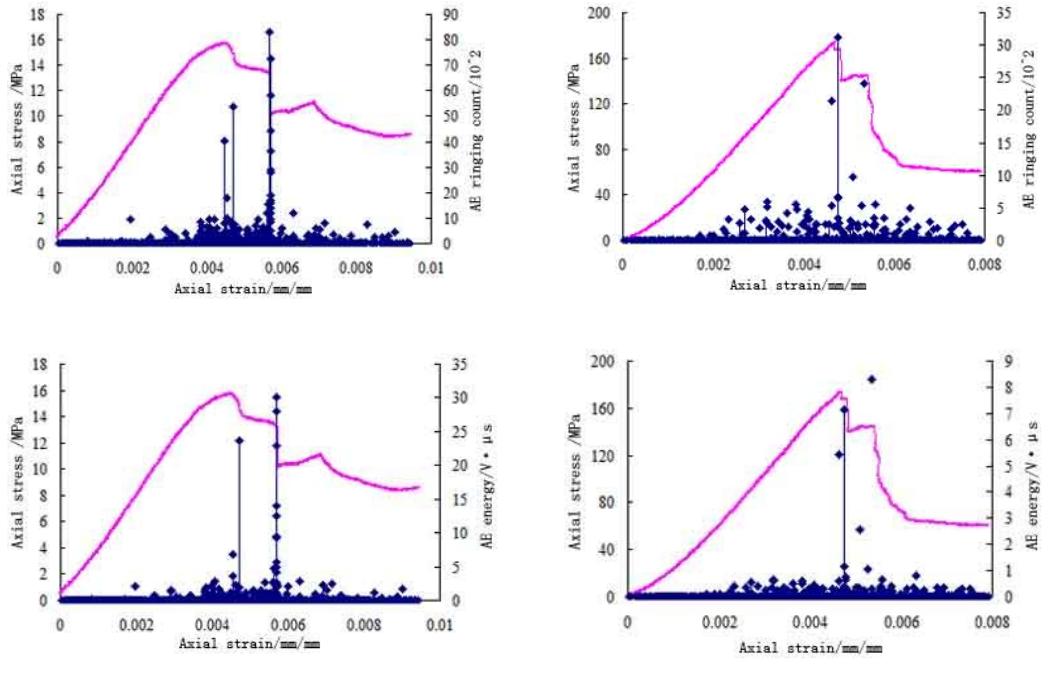
counts and energy of AE tests are respectively 8326, $19.9V\cdot\mu s$ and $5230, 15.6V\cdot\mu s$ when detector respectively was installed inside and outside the triaxial chamber, the maximum ringing counts and energy of the former is respectively 59% and 28% higher than the latter.

The test results indicate that shear wave produced in the process of compression fracture could be unable to through the hydraulic oil directly, the number of AE events and energy receiving decrease because of the complex propagation path.

Although the longitudinal wave could propagate in the liquid normally, the increase of transmission distance and the reflection of triaxial chamber results in energy attenuation. Therefore, in the same test conditions and environments, comprehensive and reliable AE signals could be received when the AE detector was installed inside the triaxial chamber.



(a)outside triaxial chamber



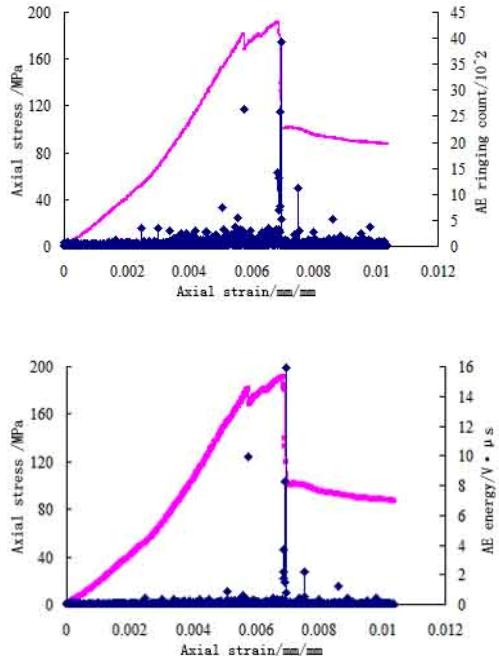
(b)inside the triaxial chamber

(a) confining pressure is 6MPa

Fig.2 AE test results with the detector installed inside and outside triaxial chamber

5. AE characteristics of coal damage evolution under triaxial compression

AE information can reflect the internal damage of rock better, and it is closely related to evolution process of initial fissure compaction, new crack initiation, extension and penetration. Using the above acoustic emission test methods under triaxial compression, analyzing AE characteristics in the process of axial compression failure under different confining pressure through ringing counts and energy which could respectively reflect the frequency and amplitude of AE. Test results of AE ringing counts and energy under the condition of confining pressure is 6MPa and 9MPa are shown in Fig.3, results of confining pressure 3MPa are shown in Fig.2.



(b) confining pressure is 9MPa

Fig.3 Test results of AE ringing counts and energy curves of coal specimens under triaxial compression

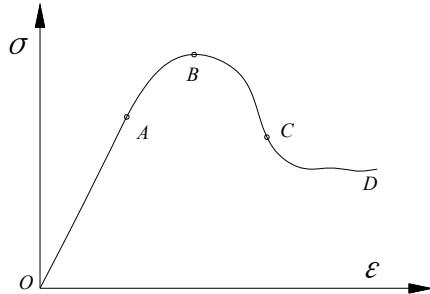


Fig.4 The complete stress-strain curve of coal specimens under triaxial compression

Based on the AE test results of the coal specimens under different confining pressure, evolution process of coal specimens deformation and failure under triaxial compression could be simplified into four stages as shown in Fig.4.

(1) In the stage of compaction and elastic(OA), stress-strain curve of coal specimens basically shows linear relation, compared with uniaxial compression, AE ringing counts decrease significantly, the ENT is low. Applying confining pressure before axial loading causes the compaction of initial fissure, improving the integrity and stiffness of coal specimens, making the compaction process of the stage is not obvious, there is no AE activity basically; with the increase of axial load, AE ringing counts begin to increase, but its energy is relatively low, smaller scale of new cracks begin to produce and extend in the specimens.

(2) In the stage of plastic failure(AB), a large number and large scale of new crack begin to appear, at the same time, a lot of strain energy accumulates within the coal specimens, in the process of energy release, AE ringing counts increase significantly, the energy increases gradually, AE activities improve further.

(3) Along with the further increase of axial load, coal specimens enter the stage of fracture and its development(BC). In addition to the original crack extended further, a large number of new cracks produce in this stage, convergence of crack

and breaking through causes the formation of a macroscopic fracture surface, interaction with each other increased, AE ringing counts and energy increase rapidly. Shortly after macro failure of coal specimens, ringing counts and ENT reach the maximum value at the same time.

(4) After entering the stage of plastic flow(CD), the coal sample still has carrying capacity to a certain extent, with the increase of the axial load, there are still many secondary cracks produced and extended in the coal specimens in addition to main cracks, acoustic emission ringing counts and energy are still in a high level.

6. Main conclusions

(1) The maximum ringing counts and energy of installing the detector inside the triaxial chamber is respectively 59% and 28% higher than installing detector outside the triaxial chamber. More comprehensive and reliable AE signals could be received when the detector was installed inside the triaxial chamber.

(2) On the basis of developing the pressure plate using for placing AE detector and refitting the communication interface of rock mechanical test system, achieving the reasonable triaxial compression AE test with the detector installed inside the triaxial chamber.

(3) According to the AE characteristics of rock damage fracture under triaxial compression, evolution process of coal deformation and failure could be simplified into four stages as compaction and elastic, plastic failure, fracture and its development, plastic flow.

7. References

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