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ISSN 0974-5904, Volume 09, No. 06

International Journal of Earth Sciences and Engineering

December2016,P.P.2333-2337

Study on Gas Drainage Hole and Whole of Coal Sample Acoustic Emission Failure Law under Complex Stress

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Abstract: Experiments on gas drainage drilling and whole of coal sample were carried out by the electro-hydraulic servo of rock triaxial test systems and the acoustic emission (AE) system. The test results indicate that coal sample including gas drainage borehole is first the borehole unstability which leads to the whole instability, complete coal sample suddenly destroys multiple blocks. Gas drainage borehole coal sample damage duration shorter, but it appears many times. Complete coal sample happens to some serious damage that duration will reach to maximum. Complete coal sample appear AE count blank area early than gas drainage borehole coal sample. Coal sample including gas drainage borehole releases more energy than complete coal sample. Complete coal sample takes place low frequency when stresses do not change, at other times, whatever stress rising or falling peak frequency hold on around 300 KHz. coal sample including gas drainage borehole first falls existing loading blank area and damage which happens before low frequency gap area.

Keywords: *acustic emission, mechanical properties, gas drainage hole, damage*

1. Introduction

The gas drainage is one of the most direct and effective methods to solve the gas accident, the solution to the gas outburst in China is mainly through gas extraction, which produces some phenomena such as hole collapse and sticking restricts, and at the same time is caused a serous threat by the production and security. Study surrounding coal and rock failure rules around the gas drainage can be solved. Many scholars regarded that briquette and the raw coal difference are apparent between the proportion and the real specific gravity，The porosity and pore volume are between 4 times and 4 ~ 10 times. But its change rule has rather a good consistency; the briquette can be used as research object coal general regularity because of easy processing and high success rate (Shining Zhou，Baiquan Lin,1990). Coal elastic wave was released a phenomenon of crack propagation by using Acoustic emission. The deformation of coal occurred by the internal primary crack extension and with the new crack appeared, and then its accompanying energy was released. The crack tip transmitted all sides that were accepted by the acoustic emission probe and surface which caused mechanical vibration. Mechanical signals were converted to electrical signals, through the software of processing and analyses, converting a series of electrical signals that are stored in the computer to magnify and collect record. The coal and rock mass had been studied the process of destruction by an increase number of acoustic emission. Cheng Yuan-ping (Cheng Yuan-ping，Fu Jian-hua，Yu Qi-xiang，2009) considered that the burst tendency for coal samples was carried out the experiences by using conventional uniaxial and triaxial and triaxial unloading confining pressure that it was in different stress paths studied the deformation and failure process of coal samples Acoustic Emission (AE). Xiao Fu-kun (Xiao Fu-kun, Zhao Xiang-shun) studied that it was a test by AE that monitoring the whole process of compressive deformation under different coal moisture content . Gioda G (Gioda G，Swoboda G，1999) studied the coal and rock deformation under uniaxial compression damage and AE characteristics. Yang Yong-jie(Negro A，de Queiroz PIB，2000，Swoboda G，Mertz W，Schmid A，1989) studied the outburst coal deformation and destruction analysis on the comprehensive AE characteristics, during uniaxial compression, the deformation of coal samples was researched. Swoboda G (Swoboda G，Abu-Krisha A,1999) researched during uniaxial compression the AE spectral characteristics of coal samples deformation. Dou Lin-ming (Callari C，2002) investigated that coal and rock impact destructive model of acoustic-electric precursor analysis of regularity. Xiao Fu-kun(Xiao Fukun，Liu Gang，2014) deemed the coal sample including gas was carried out the macroscopic mechanical analysis of the experimental study of AE during the loading process. LIU Gang(LIU Gang，ZHANG Yanjun，SHEN Zhiliang，WANG Yifei，YU Han，LIU Hongwei，2015) is concerned with an evaluation of the granite crack extension corresponding damage. The evaluation is performed by using the whole

stress-strain curve and acoustic emission signal under uniaxial compression of granite sample and applying the AE energy and AE count and stress-strain curve integral gain energy and thereby obtaining data interpolation using the same time theory; WU Xianzhen（WU Xianzhen，LIU Jianwei，LIU Xiangxin，ZHAO Kui，ZHANG Yanbo，2015）in order to study the relationship between acoustic emission characteristic parameters and strain, stress and damage variable of rock under different failure models, the tests have been made to obtain the characteristics of acoustic emission of sandstone, leptynite, granite and limestone using hydraulic-pressure servo testing system RMT-150C and acoustic emission instrument SAEU2S under the uniaxial compression.

These researches resulted from the mastering breakdown of coal and rock as an important reference value, but the destructive regulation of gas drainage drilling that had not been formed AE characteristics. Studying failure process of AE characters on a complete coal and coal samples contained holes that revealed coal between deformation and strength and crack propagation and AE characteristics of the relationship. In order to contrast drilling results, the influence of raw coal and coal sample containing gas drainage borehole were analyzed. To further study of coal and rock fracture law an important foundation and prerequisite in which gas drainage has important theoretical and practical significance.

2. Experimental Equipment and Experimental Process

Coal and rock testing researches AE that main carried out the macroscopic mechanical properties test. Coal samples were under the different stress in conditions stress-strain and AE characteristic in loading the process of recording. Analysis of AE parameters was the relation between strain and stress for AE parameters extraction. Comprehensive analysis that revealed the damage evolution was in the process of deformation and failure of coal sample.

1) Test equipment and sample preparation

Testing equipment is made from TAW-2000KN computer controlled servo triaxial testing systems and the U.S. company AE Physical Acoustics monitoring system for three-dimensional positioning components (Figure1). TAW-2000KN computer was controlled servo triaxial testing systems that are fully automatic digital computer controlled system with real-time record loading, stress, and displacement and strain values. It was able to draw simultaneously load-displacement, stress-strain curve. AE display system could automatically count on AE events and store and achieve real-time monitoring of acoustic emission.

Experimental coal samples were selected from Jixi in Heilongjiang Province. According to "coal and rock of physical and mechanical properties test method" (GB/T23561-2010) provides that high aspect ratio of coal sample specimen is 2.0. By double-face polished machine deals with coal standard test pieces to refer the size of 50×50×100mm to diameter tolerance of less than 0.2mm and the surface tolerance of less than 0.05mm across the unevenness of the end face and perpendicular to the axis deviation does not exceed ± 0.25 °. The coal samples are hit a drill hole diameter of 15mm. In order to eliminate the interference signal the beginning of loading specimen and AE contact points polishing so that more effective AE sensors receiving specimens were issued when the internal crack were received the AE signal, and ensure the coupling of results between the specimen and the sensor contact can be coated the coupling agent. The Table 1 was shown the mechanical properties of the coal samples. In response to contrast drilling results, the influence of raw coal and coal samples containing gas drainage borehole were analyzed. Coal-0 is a complete coal sample; 13 coal samples including gas drainage borehole were from coal-1 to coal coal-14.

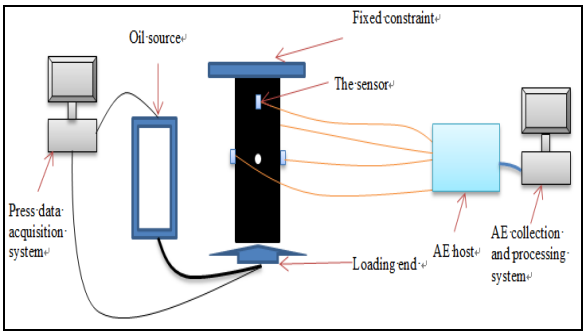

Fig1: *TAW-2000KN Hydraulic servo triaxial testing system and SH- Ⅱthree-dimensional positioning real-time monitoring of acoustic emission testing system*

Table 1: *Mechanical properties of the coal samples*

Sample no.	Sample size(mm)（L×W×H）	Area(mm²)	Fracture load(KN)	compressive strength(MPa)
coal-0	53.65×53.28×103.76	2858.47	36.621	12.811
coal-1	53.70×54.10×103.92	2905.17	28.348	9.758
coal-2	53.34×53.62×103.68	2860.09	27.494	9.613
coal-3	53.85×53.03×104.22	2855.67	24.844	8.7
coal-4	53.62×53.64×103.98	2876.18	25.234	8.773
coal-5	53.70×53.60×104.40	2878.32	19.155	6.655
coal-6	53.87×53.52×104.25	2883.12	28.324	9.824
coal-7	53.77×53.62×104.30	2883.15	28.789	9.985
coal-8	53.76×53.66×104.54	2885.3	31.359	10.869
coal-9	53.78×53.71×104.24	2834.22	36.186	12.767
coal-10	54.36×54.20×103.56	2946.31	24.289	8.244
coal-11	53.68×53.52×103.54	2872.95	33.461	11.647
coal-12	53.12×53.54×104.94	2844.04	22.785	9.029
coal-13	54.72×53.18×102.93	2910.01	26.147	9.299
coal-14	53.38×54.12×102.72	2888.93	30.966	10.719
average	□	2880.25	27.670	9.706

2) Testing Process

Test loading speed is used in all of axial displacement mode load 0.02mm/min. Rock testing machine and acoustic emission device are 50μm sampling interval. To reduce outside noise interference acoustic emission thresholds set 45-500KHz sampling. Uniaxial: acoustic emission sensors mounted on the side the coal sample and filled with a coupling agent

gap. Experimental damage result picture was shown in figure 2.

3) Coal sample failure process analysis

With the loading speed increasing, gas drainage borehole coal sample appear squeaking noise, and then the top left corner crack start extension forming local buckling. The hole wall crack appears 45° transfixion on the right side of and the second the upper half hole position, due to the role of internal cracks appear vertical crack. This part of the area complete be well versed, lead to coal samples borehole near instability, especially drilling surface collapse splash block, borehole surrounding just lose bearing capacity, borehole turn from round to oval. The hole area and near area with mutual induction, the more weak area prompte weak area, coal sample completely failure in central that this point reach at the end of the experiment. Complete coal sample broken into multiple blocks, it happen to transient instability, there is not multistage fall. The results of contast for figure 2 (a) and (b). The experimental samples are prepared to Figure 3. gas drainage borehole coal sample the borehole unstability lead to the whole instability, complete coal sample sudden destroy multiple blocks.

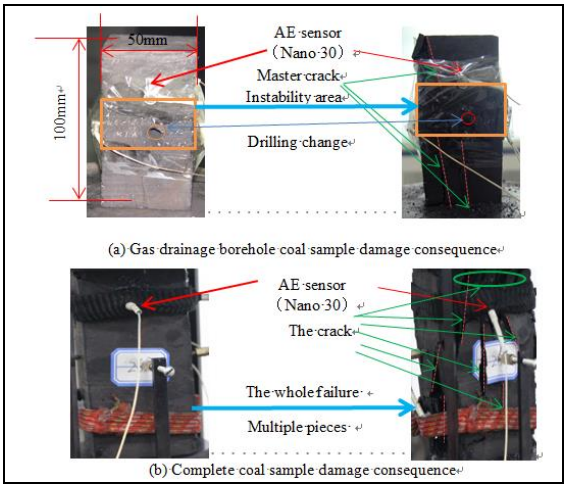

Fig. 2 *Complete coal sample and gas drainage borehole coal sample damage form contrast*

Fig. 3 *Punch coal sample photos*

3. Coal Comparative Analysis of Deformation and Acoustic Emission

By experienced analysis method studied coal under uniaxial compression injury of AE signal analysis. The relationship was the parameters signal parameters according to their respective analysis come to between stress-strain and acoustic emission characteristics. To simulate the formation actual situation study the coal containing gas drainage drilling triaxial compression acoustic emission testing. Loading speed and control methods are same uniaxial loading for ease of analysis.

Huang and hong (2) proposed a method for predicating bearing capacity ratio of reinforced sand with high tensile stiffness reinforcement at ultimate footing load. They reported the linear relationship between settlement reduction factor and bearing capacity ratio.

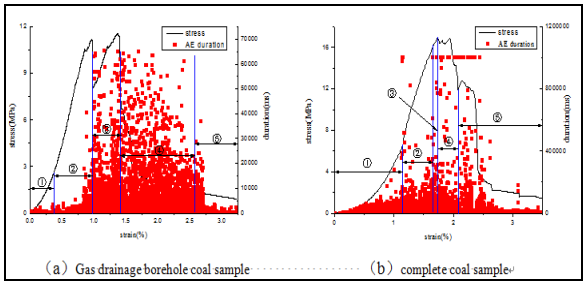

Fig. 4 *Gas drainage borehole coal sample and complete coal sample strain-stress curve and AE duration relation*

As shown in figure 4(a) that through analysis of the stress-strain curve of coal sample gas drainage borehole can be divided into five stages, the first stage is the compaction stage, the second stage is the elastic stage, the third stage is the plastic stage, the fourth stage is peak stage, the fifth stage is residual stress stage. The coal sample is happen to twice stress induce, The first, it is a 45° damage that leads to cure fail, the second damage is in the middle of the overall instability of the whole coal sample. The AE duration is consistent with stress-strain. Initial consolidation stage, the acoustic emission duration is more shorter, when reach to the elastic stage, AE duration is increasing, the inelastic phase appear after stress drop, the acoustic emission duration is significantly longer, the destruction is the stage, the peak reach to duration of acoustic emission and the residual stress stage, duration of acoustic emission enter into the trough. As shown in figure 4(b) that complete coal sample always can be divided into five stages，stress appear decline when it happen at the end of phase 1, the time duration instantaneous growth. the duration and destruction is proportional to fit. It reach to the inelastic phase(the stage 3), the duration increase significantly. The peak load appear the fall, the stage 4duration have a stable high level. With the damage rise in stage 5, the whole duration is gradually weakened. Gas drainage borehole coal sample damage duration more shorter, but it appear mang times. complete coal sample happen to serious damage that duration will reach to maximum.

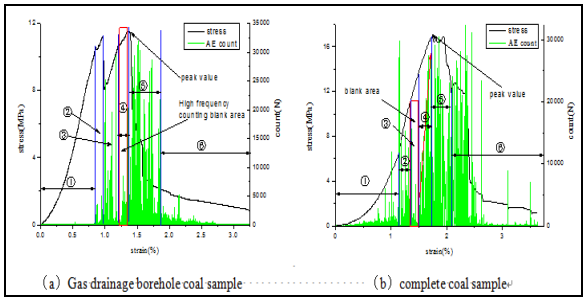

Fig. 5 *Coal sample strain-stress curve and AE count relation*

As shown in figure 5(a). Strain-stress curve and AE count relation of coal sample including gas drainage borehole can be known. With the increase of loading and it reaches before the elastic stage, with AE counts been increasing, the first drop peaks counts. With the increase of plastic stage, AE counts reduce gradually until the early damage, there is an obvious blank stage. When happened to failure stage of load falling process, acoustic emission counts keep value the higher until the moment to the residual stress, with the increase of strain, acoustic emission counts of residual stress late stage present linear decline until vanishing. We can find that loading and acoustic emission technology has a good corresponding relation, and the blank period forecast coal sample including gas drainage borehole destruction has an important significance. As shown in figure 5(b) that can be divided into six stages, the first count peak appears at the end of the 1~2 stages. The 3 stage finds a blank period; coal sample indication will be destroyed. The 4 stage has AE counts in a steady rise, the stable high count exist a period of time after peak. Through analysis of the AE counts that the 6 stage damages gradually weakened. Complete destructive coal sample appears AE count blank area early than coal sample including gas drainage borehole does.

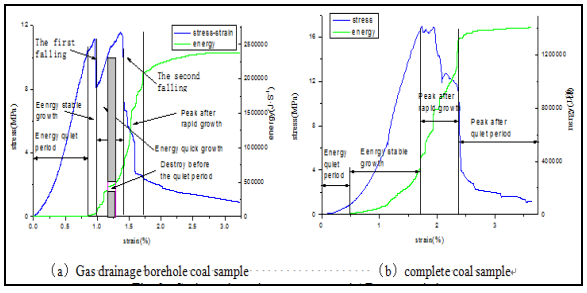

Fig. 6 *Coal sample strain-stress curve and AE energy relation*

As shown in figure 6(a) that Strain-stress curve and AE energy relation of coal sample including gas drainage borehole can be realized. AE energy starts to appear energy quiet period, with the first fall coming, AE energy presents a rising tendency, when falling between the second drop and the first time, AE energy grows more quickly than the first time fall, but it exists a plateau, the damage can be characterized through the plateau. AE energy rises sharply destroy the instantaneous, stress rapid decline phase that the energy continues to grow; stress reaches a stable stage that the AE energy holds on stable. As shown in figure 6(a) that complete destructive coal sample can be divided four stages, the first stage is energy quiet period, the second stage is energy stable growth, the third stage is peak after rapid growth, the fourth is peak after quiet period. Two kinds of coal samples have a similar law in AE energy changes; it is a difference gas drainage borehole coal sample exist a plateau, gas drainage borehole coal sample releases more energy than complete coal sample.

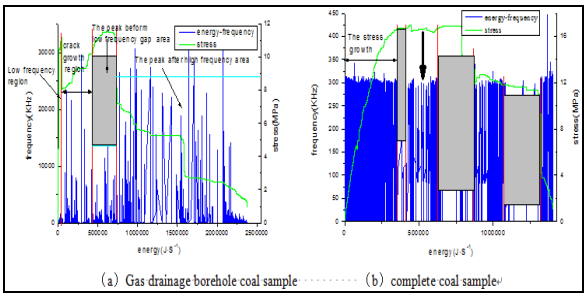

Fig. 7 *Coal sample AE energy and AE frequency relation*

Through the figure 7(a) can see the relationship between the AE energy-frequency-stress. With the AE energy increase, stress reach to the first fall before frequency lie to low frequency region. When fall between the second drop and the first time, crack growth region high frequency event increase following by a high frequency blank period, the time is peak value, high frequency region always continuous when lie to after the peak. Through the figure 7(b) that the AE energy add up proess, the frequency always hold on 300KHz around, but it exist some special region, when stress do not happen change in a certain condition, the frequency have a low blank area at this time. The special region total to appear three times that explain the law. Two kind of coal sample analysis to base on energy of frequency-stress change characteristic, they have obvious differences, complete coal sample take place low frequency when stress do not change, at other times, whatever stress rising or falling peak frequency hold on 300KHz around. Gas drainage borehole coal sample first fall exist load blank area and damage happen before low frequency gap area.

4. The Circuit

Coal sample including gas drainage borehole is first the borehole unstability which leads to the whole instability, complete coal sample suddenly destroys multiple blocks. Gas drainage borehole coal sample damage duration shorter, but it appears many times. Complete coal sample happens to some serious damage that duration will reach to maximum. Complete coal sample appear AE count blank area early than gas drainage borehole coal sample. Coal sample including gas drainage borehole releases more

energy than complete coal sample. Complete coal sample takes place low frequency when stresses do not change, at other times, whatever stress rising or falling peak frequency hold on around 300 KHz. coal sample including gas drainage borehole first falls existing loading blank area and damage which happens before low frequency gap area.

5. Acknowledgements

This research is supported by Heilongjiang Ground Pressure & Gas control in Deep Mining Key Lab Open Topic (The study of AE characterization impact combined coal and rock) in Heilongjiang University of Science and Technology, The national natural science foundation of China (51374097), China postdoctoral science foundation (2014M561384), Science and technology research key project of heilongjiang province department of education (12541z009). The authors would like to thank all members for my help with the field work in Heilongjiang Ground Pressure & Gas Control in Deep Mining Key Lab (GPGC); the excellent collaboration of all participants is highly appreciated.

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