Observation and research on surface crack structure of coal based on electronic scanning technology

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Abstract. Based on the background of the 2 # coal seam mainly mined by Caojiatan Coal Mine in Yulin Mining Area in northern Shaanxi, this paper adopts the Scanning electron microscope test method to obtain the fracture size and structural characteristics of coal samples through the process of sample preparation drying testing analysis. After testing, the cracks in the main coal seam samples of Yulin mining area in northern Shaanxi show irregular distribution, with small branch cracks mainly derived from larger main cracks. The closed form crack structure is a wedge-shaped structure, while the open form crack width is in an disordered state. Some cracks have no fixed width or size, and the main crack width range is 90μm~617μm, the width range of branch fine cracks is 0-21 μm; It can provide basic support for the application of water injection dust reduction engineering in the later stage.

Keywords: Yulin mining area in china;Scanning electron microscopy;Crack scale;Structure characteristics.

1. Introduction

Coal is the cornerstone of energy security in China. In recent years, the annual production of coal has exceeded 4 billion tons, and the intensity of mining is constantly increasing. The resulting dust hazards are also becoming increasingly prominent, seriously endangering the physical health of workers [1-2]. In recent years, with the national emphasis on the prevention and control of occupational diseases caused by coal mine dust, a series of dust prevention and control management regulations and standards have been issued, effectively curbing the rising trend of coal workers' pneumoconiosis. The number of new pneumoconiosis patients each year is gradually declining, but the number of new pneumoconiosis patients each year still reaches tens of thousands, and the form of Occupational hazard is still not optimistic. The primary culprit causing pneumoconiosis is respiratory dust, and coal seam water injection is the most effective and direct dust prevention method to reduce the production of respiratory dust during coal mining production [3]. Coal seam water injection increases the moisture content of the coal body by pre wetting it before mining, reduces the ability of fine particle dust to fly, changes the strength of the coal body, and thus reduces the dust production during coal cutting during the mining process [4].

Coal is a disordered and non-uniform porous medium, and coal fractures are the phenomenon of cracking caused by various natural stresses during the coal formation stage, which is a natural attribute of coal bodies [5-7]. The effectiveness of coal seam water injection is directly related to the occurrence characteristics of the coal seam itself. The pores in the coal body are the storage and transportation channels of water in the coal seam, and their structural characteristics (such as the number of pores, individual pore size, pore distribution characteristics, and pore connectivity, etc.) directly affect the effectiveness of coal seam water injection [8-9]. The size of cracks has a direct impact on the increase in water content during coal injection. Therefore, in order to inject water into coal, it is necessary to clarify the scale range and structural characteristics of coal cracks, and provide theoretical reference for the selection of water injection process parameters.

Yulin mining area in northern Shaanxi is the main coal producing area in China, with high degree of mechanization, high mining intensity, and urgent demand for dust control. Therefore, this paper takes the coal seam mining in Yulin mining area in northern Shaanxi as the background, and uses Scanning electron microscope to carry out the test of coal fracture size and structural characteristics, providing data support for the future application of water injection dust reduction engineering.

2. Testing principles

Scanning electron microscope is an observation method between Transmission electron microscopy and optical microscope. It uses a narrow focused high-energy electron beam to scan the sample, excites various physical information through the interaction between the beam and the material, collects, amplifies, and reimagines this information to achieve the purpose of characterizing the microscopic morphology of the material. It is widely used to observe the morphology and composition of the surface microstructure of various solid substances [10-12].

Its working principle is mainly that the electron beam emitted from the electron gun converges into an electron beam with a diameter of 5 nm under the action of the acceleration voltage and the magnetic lens system. After passing through the Electron optics system composed of two to three electromagnetic lenses, the electron beam converges into an extremely fine electron beam focused on the sample surface, and the scanning coil is used to scan the electron beam on the sample surface; The interaction between the high-energy electron beam and the sample material will generate various signals such as Secondary electrons, back reflection electron, absorption electron, X-ray, Auger electron, cathodoluminescence and transmission electron; After being received and amplified by the receiver, these signals are sent to the gate of the picture tube to modulate the brightness of the picture tube. As the current on the scanning coil corresponds to the corresponding brightness of the picture tube one by one, when the electron beam hits a point on the sample, a bright spot appears on the fluorescent screen of the picture tube. By using a point by point imaging method, various characteristic images of the sample surface are observed.

3. Testing system

In this paper, KYKY-EM6900 Scanning electron microscope is used to measure the fracture size of coal samples. The system is mainly composed of a mirror cylinder host, an electrical cabinet, a computer, a small ion sputtering instrument, a mechanical pump air compressor, and a backscatter detector. The observation resolution of the system can reach 3nm, with a magnification range of 6x-3000000. It can achieve omnidirectional scanning measurement of multiple coal rock samples and obtain true surface structure information of coal rock samples. The electron microscope structure is shown in Figure 1.

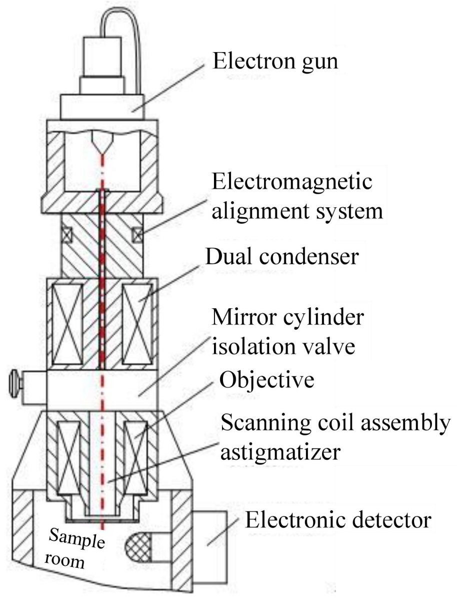

Figure 1. Electron microscope structure

Obtain coal block samples with each side length greater than 300mm on site. In order to ensure the authenticity of observed sample cracks to the greatest extent, a wire cutting process is used to cut and remove the peripheral broken coal blocks from the retrieved block coal. Only 50mm~100mm cubic coal samples are retained in the central area of the block coal, and on this basis,φ25mm×50mm cylindrical coal sample was observed for surface cracks using scanning electron microscopy.

Figure 2. Processing and making coal samples

The sample was dried at low temperature, treated with gold spray, and placed in the scanning electron microscope sample chamber. After the vacuum was pumped to a threshold of 5.0 * 10-5 Torr, the cracks were observed.

4. Crack scale analysis

Coal is a Porous medium, which contains a large number of pores and fissures. Pores and fissures are the channels through which water flows in the process of water injection. Due to the complex and changeable internal structure of Porous medium and the size of fissures, it is a good choice to test with scanning electron microscope, which has been widely used in recent years.

This paper selects 9 sets of coal samples for observation. Through statistical analysis, it is found that the cracks in the coal samples exhibit irregular distribution, with small branch cracks mainly derived from larger main cracks. The closed form of the crack structure is a wedge-shaped structure, with a wider gap in the middle area and narrower at both ends. The cracks gradually close from the middle to both ends, forming a closed crack. Due to limitations in the size of coal samples, the observed open crack morphology and width exhibit a disordered state. Some cracks have a fixed width and size, while others have wider and narrower areas, resulting in disorderly distribution; At the same time, some sample cracks show a consistent trend of narrowing from width. The fracture morphology is shown in Figure 3.

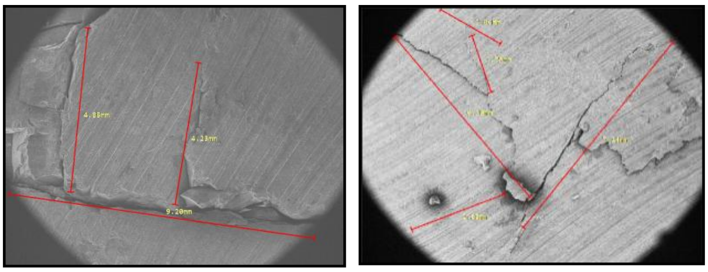

Figure 3. Observation of crack morphology

By amplifying the measurement of the observed sample, the width range of the main crack in the coal sample is within 90 μ M~617 μ Between m, the width range of branch fine cracks is 0-21 μ Due to the size limitation of the specimen, the crack length will not be counted here due to the variation between m. The observation scale of some sample cracks is shown in Figure 4.

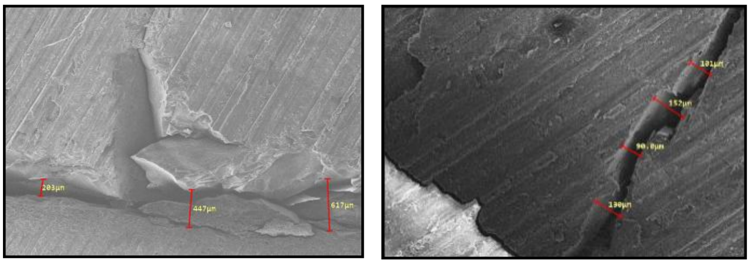

Figure 4. Observation of crack scale

5. Conclusions

Using scanning electron microscopy technology, the scale of cracks in the main mining seam 2 # in Yulin mining area, northern Shaanxi was tested. After testing, it was found that the cracks in the coal sample showed irregular distribution, and the small branch cracks were mainly derived from the larger main cracks.

The closed fracture structure presents a wedge-shaped structure, while the open fracture width presents an disordered state, with some fractures having no fixed width or size.

Through magnification observation, the width range of the main cracks on the surface of the main coal seam in this area is within 90 μ M~617 μ Between m, the width range of branch fine cracks is 0-21 μ The changes between m can provide basic support for the later application of water injection dust reduction engineering.

Acknowledgements

This work was sponsored by Natural Science Foundation of Chongqing,China (cstc2021jcyj-msxmX1184).

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