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Characteristics of Coal-Containing Bedding Structure's Dynamic Fracture Mechanics and Energy Distribution Rate Response

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Abstract

A split Hopkinson bar was used to determine the fracture characteristics of coal samples with various bedding angles in order to explore the effects of bedding structure and various loading rates on the dynamic fracture characteristics and energy dissipation of Datong coal. The high-speed camera captured the crack start and propagation phase in Datong coal [1]. On the basis of the finite element method (FEM) and the J-integral, the formula for the model I fracture toughness of the transversely isotropic material is produced. The characteristics of energy dissipation during the dynamic fracture process of coal, taking the bedding structure into consideration, are obtained by comparing the incident energy, absorbed energy, fracture energy, and residual kinetic energy of Datong coal samples under varied impact speeds. According to the experimental findings, the fracture pattern of Datong coal's notched semi-circular bending (NSCB) represents a tensile failure. The coal sample splits into two pieces and rotates somewhat equally around the spot where it made contact with the incident rod. For Datong coal, the dynamic fracture toughness is 3.52 to 8.64 times greater than the quasi-static fracture toughness [2]. With increasing impact velocity, dynamic fracture toughness rises, and the impact of bedding angle on fracture toughness then falls. Additionally, as the impact speed increases, the residual kinetic energy of coal samples with the same bedding angle rises. The overall statistical data dispersion and energy consumption rate are both steadily declining. Regardless of energy utilization effectiveness or fracture toughness, low-speed loading is the preferred loading condition in rock fragmentation engineering. These findings could have a big impact on how hydraulic fracturing works in coal mass optimization and how to better understand how cracks spread during coal bed methane extraction (CME). Both of these situations call for careful consideration of coal's anisotropic effect [3].

Keywords: Datong coal; Methane extraction; Cyanurate Polymers; Coal-rock fracture; Silicon

Introduction

The ability to withstand brittle coal fracture under high strain rate is referred to as coal's dynamic fracture toughness. In mining engineering, accurate acquisition of the dynamic fracture toughness is crucial for controlling coal and rock stability, supporting roadways, and preventing rock bursts. Researchers have so far used a split Hopkinson bar to investigate the dynamic fracture toughness of a variety of rock materials, including granite, marble, gabbro, limestone, asphalt mixture, sandstone, shale, concrete, ceramics, and glass. On the fracture properties of coal under dynamic loads, there are, however, few reports.

The law of thermodynamics also states that the primary characteristic of a physical reaction of matter is the transition of energy. Studying the energy dissipation law in the process of coal-rock fracture under impact load and the connection between that law and coal-rock fracture instability is extremely important [4]. This may effectively increase the energy usage efficiency of roadway excavation, borehole blasting, and cutting from the standpoint of energy utilisation. It is also beneficial to researching the mechanism of dynamic disasters such coal bump, coal and gas eruption, and rock burst. In an effort to understand the deformation and failure behaviour of rock from an energy point of view, academics have recently conducted a great deal of research on the energy dissipation characteristic of the rock fracture process [5]. SEM was used to examine the crack branching behaviours of marble and gabbro under various loading rates. A split Hopkinson bar and high-speed camera were also used to analyse the energy dissipation features of the dynamic fracture process of short bar rock samples. Sandstone was subjected to a plane impact test by Gao W X and colleagues using a single stage light gas pistol, and the damage energy dissipation density of sandstone under various impact loads were estimated. Using a split Hopkinson pressure bar with high temperature device, Xu J. Y. et al. investigated the energy dissipation properties of marble at various high temperatures and examined the correlation between the fractal dimension of impact fragmentation and energy dissipation. In the spectrum of static loading rates, Huang D et al. tested coarse-grained marble in uniaxial compression at nine distinct strain rates. Analysis was done on how strain rates affected strength, elastic modulus, deformation modulus, failure modes, stress-strain curves, and other variables. Medium carbon high silicon high strength steel that underwent the austempering process at 240, 360, and 400°C was the topic of an investigation by Chen K. and colleagues on the development of multiphase microstructure and impact fracture behaviour [6]. The findings indicate that while the impact toughness initially rose and then fell with temperature, the average carbon concentration in the matrix declined as the temperature climbed. Additionally, numerical simulation and fracture toughness testing have been extensively used to study the fracture behaviours of non-rock materials such as silicon, aluminium, concrete, PMMA, and other non-rock materials at quasi-static or dynamic rates. In conclusion, research on anisotropic coal-rock materials with bedding structure is scarce compared to isotropic rock materials and other non-rock materials. Due to coal bedding, the

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mechanical properties of coal exhibit clear anisotropy, which is crucial for the stability analysis of coal mass and road construction [7]. Testing dynamic fracture features and researching the impact of coal bedding on its energy dissipation law are therefore important.

The dynamic fracture toughness of coal samples was evaluated using the NSCB method and a split Hopkinson bar. Under dynamic impact, the fracture modes and crack propagation behaviours of coal samples with various bedding angles were thoroughly examined. On the basis of the finite element method (FEM) and the J-integral, the formula for the model I fracture toughness of the transversely isotropic material is produced. The rate response characteristics of the dynamic fracture toughness of coal samples with various bedding angles were discussed, as well as the fracture characteristics of coal samples with various bedding angles under various loading rates [8].

Methods

We selected a coal preparation facility that employs a cyclonic micro-bubble flotation column (abbreviated as FCMC), which was created and patented and is widely used in Chinese coal preparation plants, for our research on switching and optimising control for the coal flotation process. The froth zone, collecting zone, and scavenging zone are the three working zones that make up the FCMC flotation column. On top of the column, there is an overflow groove and a washing device. The inlet is situated at around one-third of the height of the column. The overflow groove is used to discharge the concentrate, while the underflow port is used to discharge the tailings. The circulation pump is located outside the column body and is attached to the air bubble generator. The bubble generator breathes air and mixes it with the frother in the coal slurry when the circulating pump jets the slurry. In the process of reducing pressure, a lot of micro bubbles are released. Under the influence of centrifugal force, micro bubbles travel rotationally as they enter the column in a tangential direction. The gas-solid floccules and bubbles that have been mineralized ascend via the rotational flow center and into the collection zone. The tailings that have not been mined descend and discharge through the underflow. The feed and air bubbles flow backwards, which encourages mineralization and the development of gas-solid floccules [9].

Column height, particle size distribution, feed ash content, concentration, flow rate, gas holdup, wash water rate, reagent dose, and foam depth are the primary influencing parameters in the FCMC flotation column process (pulp level). The quality of the coal flotation products is influenced by these factors to varying degrees (ash content and recovery). The frother dosage and the circulating pulp pressure determine the gas holdup. Coal flotation and ore flotation produce different particle size compositions, and coal flotation produces less fine particles than ore flotation [10]. In addition, using as little wash water as possible, or even none at all, is recommended by the manufacturer under the assumption that the product's quality is guaranteed. As a result, this document does not take the wash water rate into account. By increasing the minerals' hydrophobicity, reasonable reagent addition can aid in the separation of valuable minerals from gangue. Another key factor is the depth of the froth. The bubbles in a flotation column clash with the particles, which stick to them in the collection zone. The bubbles that stick to the particles make up the froth zone. The possibility that particles adhere to the bubbles can be increased by raising the collection zone, which will enhance concentrate recovery. Contrarily, by extending the froth zone, the froth depth can boost the secondary enrichment of froth flotation, hence raising the concentrate's grade. The two controllable variables in this study are the froth depth and reagent addition. The primary process variables in the coal flotation process include disturbance variables, manipulated variables, and controlled variables [11].

Result and Discussion

Coal sample dynamic fracture under impact force with various bedding angles. The dynamic fracture process of 129 coal samples was examined, and it was discovered that the coal sample failure characteristics include tensile failure. The cracks primarily propagate along the plane of the notch and impact direction. For instance, coal samples with a 45° bedding angle have a more complicated crack propagation path than other samples. The crack initially begins at the notch's tip, then spreads along the weak bedding plane until coming to an end at the intersection of the incident bar and the sample. It should be observed that the crack propagation path exhibits an uneven fractal-like feature and is not linear due to the influence of the bedding plane. Along the bedding plane, the coal sample is gradually stripped and broken down [12, 13].

In addition, the high-speed camera data from the crack initiation and penetration time, along with the sample's geometrical dimensions and groove depth, may be used to compute the fracture propagation velocity of coal samples with various bedding angles [14]. According to the experimental findings, the crack growth rate of the Datong coal sample is less than that of the Zhaogezhuang coal sample (234.03–324.88m/s) and the laurenian granite sample (268–355m/s), and it is roughly 7.76–24.06% less than that of the Fangshan marble sample (680m/s). Different testing lithology or techniques could be the root of the discrepancy. The coal sample with a bedding angle of 45° has the fastest crack growth rate, whereas the coal sample with a bedding angle of 0° has the slowest. As a result, coal sample crack development form and propagation rate are significantly impacted by the bedding plane [15].

Conclusions

It was suggested and developed to use a vibration failure technique based on a vibration failure test system and SVM to identify surface cracks in loaded coal. Histogram equalization and a hysteresis threshold technique were used to lessen the noise and emphasize the crack in accordance with the features of the surface cracks on coal and rock mass. The above sections then provide a thorough explanation of the crack feature extract and model training methods. As a result, the categorization accuracy significantly increased. The test results demonstrate the effectiveness of the suggested algorithm and model in identifying surface cracks on coal and rock mass. The suggested approach is simple to use and successful, and the suggested eight characteristics of surface cracks may be suitable for other pattern recognition.

We discovered certain flaws in the algorithm during the trial; therefore further work needs to be done. To start, it will be helpful to apply principal component analysis (PCA) to further analysis the characteristics of the crack play a significant impact in order to significantly shorten the program's run-time. Second, this paper just determines if a region is cracked or not; as a result, the type of fracture can be determined in the following phase, which may be more useful in determining the likelihood of coal and rock dynamic disasters.

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Conflict of Interest

None

References

1. Minden JS, Dowd SR, Meyer HE, Stuhler K (2009) Difference gel electrophoresis. Electrophoresis 30: 156-161.
2. Thackeray JW, White HS, Wrighton MS (1985) Poly(3-methylthiophene)-Coated Electrodes - Optical and Electrical Properties as a Function of Redox Potential and Amplification of Electrical and Chemical Signals Using Poly(3-methylthiophene)-Based Microelectrochemical Transistors. Journal of Physical Chemistry 89: 5133-5140.
3. Robinson ND, Svensson P-O, Nilsson D, Berggren M (2006) On the current saturation observed in electrochemical polymer transistors. Journal of the Electrochemical Society 153: 39-44.
4. Mortimer RJ, Dyer AL, Reynolds JR (2006) Electrochromic organic and polymeric materials for display applications. Displays 27: 2-18.
5. Isaksson J, Kjall P, Nilsson D, Robinson N, Berggren M, et al. (2007) Electronic control of Ca2+ signalling in neuronal cells using an organic electronic ion pump. Nature Materials 6: 673-679.
6. Erlandsson PG, Robinson ND (2011) Electrolysis-reducing electrodes for electrokinetic devices. Electrophoresis 32: 784-790.
7. Robinson L, Hentzell A, Robinson ND, Isaksson J, Berggren M (2006) Electrochemical wettability switches gate aqueous liquids in microfluidic systems. Lab on a Chip 6: 1277-1278.
8. Henderson RD, Guijt RM, Haddad PR, Hilder EF, Lewis TW, et al. (2010) Manufacturing and application of a fully polymeric electrophoresis chip with integrated polyaniline electrodes. Lab on a Chip 10: 1869-1872.
9. Komatsu E, Dunkley J, Nolta MR, Bennett CL, Gold B, et al. (2009) Five-year Wilkinson microwave anisotropy probe (WMAP) observations: cosmological interpretation. Ap J Supp 180: 330-376.
10. Heger A, Woosley SE (2002) The nucleosynthetic signature of population III. Ap J 567: 532-543.
11. Dunkley J, Komatsu E, Nolta MR, Spergel DN, Larson D, et al. (2009) Five-year Wilkinson microwave anisotropy probe (WMAP) observations: likelihoods and parameters from the WMAP data. Ap J Supp 180: 306–329.
12. Lewis A, Weller J, Battye R (2006) The cosmic microwave background and the ionization history of the Universe. Mon Not Roy Astron Soc 373: 561-570.
13. Thomas D, Maraston C, Bender R, Mendes de Oliveira C (2005) The epochs of early-type galaxy formation as a function of environment. Ap J 621: 673-694.
14. Kuan YJ, Charnley SB, Huang HC, Tseng WL, Kisiel Z (2003) Interstellar glycine. Ap J 593: 848-867.
15. Snyder LE, Lovas FJ, Hollis JM, Friedel DN, Jewell PR, et al. (2005) A rigorous attempt to verify interstellar glycine. Ap J 619: 914-930.