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Analysis of Gas Migration Law and Its Analysis in Mining Fracture Ellipsoid Belt from Safety Engineering

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Abstract This paper systematically reviews the recent achievements and recent developments of coal mine gas control and drainage theory and its application. It points out that the distribution pattern of overburden mining fissures and its gas migration law are the focus of future research and the realization of coal. The theoretical basis for co-production with gas safety. Based on this, combined with similar material simulation experiments and ANSYS numerical simulation, the spatial and temporal laws and distribution patterns of the overlying rock mass fissures after coal seam mining and the range and characteristics of sufficient pressure relief are analyzed. The coal-rock coupling theory and mining rock mechanics are applied. And the mass transfer theory and other derivation of the mathematical model of gas flow in the mining fracture zone, and thus the basic law of gas migration in this way, the elliptical belt provides the channel for the pressure relief gas flow and reservoir. Space is the migration and gathering zone of gas. It analyzes the layout of the drainage system from the coal seam, the adjacent coal rock formation and the gas in the goaf, and obtains the drainage of the drainage roadway (or the end of the drilling). The dynamic fracture zone can increase the gas drainage rate and gas drainage concentration and obtain a good drainage effect. It shows that the effective and safe co-production of coal and gas resources is the guarantee for the triple effect of mine safety production, new energy supply and atmospheric environmental protection, and can obtain significant economic and social benefits.

Keywords mining cracked elliptical belt; gas migration law; coal and gas safety

1. Introduction

Due to the phenomenon of Fushun mining, the first victory of China in 1993 in Beijing, Xuzhou, Yima, according to AFP, many mining areas in Zhangzhou, Pingdingshan and Datong have burst, which has brought great safety to coal mines. The blow also made the relevant departments re-evaluate the security situation in China. As the world's largest coal supplier, China's total energy consumption in 2016 was 4.36 billion tons of standard coal, an increase of 1.4% over 2015. In recent years, although the proportion of coal consumption has decreased due to the optimization of the international economic situation, environmental problems and energy consumption structure, in terms of energy consumption, China's coal consumption in 2016 is still as high as 62.0%, and oil as the second place. Consumption accounted for 18.1% [1-2]. Energy is an important material basis for supporting China's economic development. Although new energy sources have emerged in recent years and China's energy structure has been continuously adjusted, coal will remain a major component of China's energy structure in the coming decades [3]. According to the latest statistics, the average proportion of raw coal production in China's energy production in the past decade is more than 75% [4]. Since the first coal and gas outburst occurred in the Issac Colliery Loire field in France in 1843 [5], the prominent accidents have occurred in almost every coal-producing country in the world, and it has also challenged experts and managers in the field of mine safety in various countries [6-8]. China's coal mines extend deeper into the depths at a speed of 20~50m per year. About 50 pairs of mines have a depth of 800~1200m. The ground stress and gas pressure are

increasing, and the prominent disasters are becoming more and more serious. According to the results of the 2007 national coal mine gas classification, there are 647 pairs of prominent mines in the country [9]. By 2010, the number of prominent mines in the country has reached 1044 pairs. In summary, China has become the country with the most serious coal and gas outburst disasters in the world. The number and outstanding intensity of coal and gas outburst disasters are the highest in the world [10], and the coal mine safety situation is very serious. In order to meet the needs of national economic construction, it is still necessary to ensure high and stable production of coal for a long period of time [11-12]. More than 95% of China's coal is mined and mined. The annual mine excavation roadway is about 15,000km, which is a huge underground project [13]. In the past decade, due to the massive excavation of coal, shallow coal resources have slowly been banned. After entering the deep mining, the deep high adsorption force, high gas content and high gas pressure, low permeability, coal mining and so on are intertwined, threatening the safe and efficient mining of deep resources. The research of this subject will be based on the ten mines. The working surface of 24080 is the engineering background. It mainly studies a kind of dynamic disaster caused by gas outburst and impact mine pressure. By understanding the mechanism of the dynamic disaster, it can eliminate the hidden dangers of coal mine compound dynamic disasters and achieve safe coal mine production. As mining conditions become more complex, the outstanding risks are also growing, especially in complex dynamic interactions, coal mines with gas outbursts and rock bursts, becoming a single aerodynamic hazard (or pure coal and After the gas outburst), a major and complex coal mine production safety hazard. The compound power disaster is more intense and more difficult to control. This brings more difficulties and challenges to the safe production and management of coal mines. This also marks a new historical period for coal mines.

2. Study on Gas Seepage Law in Coal Seam

(1) Linear gas seepage law based on Darcy's law

In 1965, from the perspective of seepage mechanics, Academician Zhou Shining regarded the coal seam of porous media as a virtual continuum with a uniform distribution on a large scale. In China, the theory of linear gas flow based on Darcy's law was first proposed in China. It laid the theoretical foundation of China's gas research[]. In 1984, on the basis of summarizing a large number of measured work results in the early stage, a new technology for measuring the permeability coefficient of coal seams in the“drilling flow method”was established. The method and its calculation method are widely used in coal mining in China. It is a standard method for determining the gas permeability coefficient of coal seams. Guo Yongyi (1984) combined the similarity theory to study the complete solution of the gas seepage equation for the one-dimensional case, and described the isothermal adsorption of gas with the Langmuir equation, and proposed a modified gas flow equation. In 1986, Tan Xue used the gas real gas equation of state to propose a modified real gas seepage equation for coal seams. In 1988, Wei Xiaolin determined the distribution of gas pressure in a single-hole infinite circular radial flow field.

A new method for calculating the average gas permeability coefficient of coal seams with a single borehole flow in an infinite flow field is proposed and successfully applied at the coal mine site. In 1989, Xue Xuefu and Yu Chuxin [14] established the theory of coalbed gas flow and the control equation of seepage flow under the condition that the gas adsorption and desorption process of coal gas is completely reversible. Sun Peide [15-16] based on previous research results, revised and improved The mathematical model of gas flow in homogeneous coal seams is also developed. The mathematical model of gas flow in heterogeneous coal seams is also developed. The comparative analysis of numerical simulation is also carried out by computer. Since then, Sun Peide [17] applied the theory of statistical thermodynamics and quantum chemistry, combined with experimental quantitative calculation results, to obtain an empirical equation of real gas gas state that can more objectively reflect the state of free gas in coal seams. In recent years, led by Professor Sun Guangzhong The subject group applied the Daxi seepage law, discussed the flow process of gas pulverized coal two-phase flow formed by the prominent, proposed the viewpoint of "coal-gas medium mechanics", and the mechanics of deformation, permeability and strength of coal-gas medium. The characteristics of the system were studied by the academician headed by Academician Zheng Zhemin. Based on the mechanical analysis of the order of magnitude and dimension, the Darcy seepage equation was used to explain the mechanism of the coal, gas and

gas outburst, start and stop processes, pointing out the coal and gas. The prominent mechanism is due to the coupling of coal crushing start and gas seepage

(2) Nonlinear gas seepage law

The well-known fluid mechanic E. M. Allen found that the gas flow in the coal and rock mass is nonlinear in the test that Darcy's law is used to describe the gas in the uniform solid (coal). Therefore, whether the linear percolation law based on Darcy's law is applicable to the migration of gas in coal, many scholars have concluded through a large number of experiments and theoretical studies that the deviation of Darcy's law is 1 flow is too large; 2 molecules Effect; 3 ion effect; 4 gas adsorption. Many nonlinear Darcy's laws are proposed. The expressions of these laws can be divided into four categories: 1 quadratic; 2 powers; 3 curves; 4 statistical expressions. Subsequently, these nonlinear Darcy's laws have been applied in many aspects of coal seam gas migration. For example, in 1987, Sun Peide established a compressible gas under the condition of homogeneous coal and heterogeneous coal seams based on the power law. The mathematical model of the flow in the coal seam is based on the measured gas flow parameters of the Ma Village Mine of Jiaozuo Mining Bureau. In the numerical simulation of the different models of the gas flow in the homogeneous gas field, it is concluded that the power law is more in line with the gas flow in the coal seam. Luo Xinrong [18] experimentally studied the modified Darcy's law based on the Klinkenberg effect, pointed out the application range of Darcy's law, and proposed the nonlinear gas seepage law and the corresponding mathematical model. Later, Luo Xinrong [19-20]. The gas migration and numerical simulation equations of heterogeneous compressible coal seams were established and the gas pressure distribution curve of coal seam and the gas emission curve of coal (hole) wall were obtained.

3. Study on Gas Coupling Law of Multiphysics Coal and Rock

In recent years, most scholars engaged in the study of coal-rock gas coupling law have noticed that this theory should consider the effects of geostress field, geomagnetic field and temperature field on gas seepage field. In foreign countries, W.H. Somerton [21] studied that coal permeability is related to the stress and stress history, and its air permeability decreases exponentially with the increase of ground stress. VV Khodot [22], S. Harpalani [23] and other experts and scholars, under real conditions, studied the mechanical properties of gas-bearing coal samples in geophysical fields and coal and rock mass and gas. In addition to the solid-gas mechanical effect between seepage, S. Harpalani [24] also studied in depth the permeability characteristics of gas-bearing coal samples under load conditions. Enever et al. [25] studied the permeability and effectiveness of Australian gas-bearing coal seams. The interaction between stresses shows that the change of coal seam permeability and the change of ground stress are exponential in China. Since the 1980s, Academician Zhou Shining, Academician Xian Xuefu, Professor Lin Baiquan systematically studied the gas-bearing coal. Mechanical properties such as deformation law and coal sample permeability. Zhao Yangsheng, Qi Zhongming, Hu Yaoqing and others [26], through the penetration, deformation and strength tests of high gas containing coal, obtained the axial pressure, side pressure, gas pressure on the gas.

4. Influence law of coal seam characteristics

Zhou Shining and He Xueqiu, under the auspices of the National Natural Science Foundation of China, used hot-pressed briquette as a sample to study the rheological properties of gas-containing coal and obtained a creep characteristic curve similar to rock properties. These research work is considered in China. The theory of gas flow in multi-field coupling such as stress field, geomagnetic field and temperature field provides the basic basis.

In 1994, based on the previous research work, Zhao Yangsheng proposed a mathematical model for consolidation of coal seam gas flow, systematically improved the mathematical model of coupled coal-solid gas and its numerical solution, and then based on rock mass matrix rock and fracture deformation. The physical mechanism of gas seepage and interaction, the mathematical model of rock mass deformation and gas coupling in block-fracture medium and its numerical solution. Zhang Mengtao and Liang Bing from 1995 onwards, the internal variable theory based on plastic mechanics, with gas-bearing coal mechanics Based on the study, the influence of the coupling effect of coal and gas on coal and gas outburst and the instability mechanism are

highlighted. The theory of solid-flow coupling instability of coal and gas outburst is proposed, and the mathematical model of solid-gas coupling for gas outburst is further developed. Based on the multi-phase medium mechanics, based on the second law of thermodynamics, the mathematical model of the coupled instability of solid-phase two-phase medium with coal and gas outburst is established based on the second-order work of stress as the criterion for the prominent occurrence. Finite element equation, and numerical simulation of the migration law of gas discharged from pressure in the stope by Professor Li Shugang [27]. Based on the understanding of the impact of mine pressure, the coal and rock mass is regarded as a deformable medium. According to the results of mine pressure observation and gas monitoring of multiple wells in the Weijiadi Mine of Jingyuan Coal Industry Company, the comprehensive research is carried out. Under the pressure of mining mines, considering the influence law of coal rock mass deformation on gas migration, it provides a theoretical basis for effective prevention and control of gas accidents in fully mechanized caving face and reasonable extraction and utilization of gas resources. Then, with the modern electro-hydraulic servo rock mechanics test system, the soft coal sample permeability test of the full stress strain process was carried out by numerically controlled transient infiltration method, and the coal sample permeability and principal stress difference, axial strain and volume strain were obtained.

5. Study on the Theory of Coal Mine Pressure Relief Gas Flow

After the coal seam is mined, a gas pressure gradient field is formed between the surrounding rock and the goaf of the mining layer, so that the pressure relief gas of the adjacent layer flows to the gob of the mining layer. This is a new direction to study the law of gas migration in recent years.

In China, Liang Bing and Zhang Mengtao proposed that the gas flow is regarded as the coupled mathematical model of the flow of compressible fluid in the deformable solid skeleton, and the gas flow in the coal seam under the influence of mining is studied, and the mining of No. 7 coal seam in Datong Mine is studied. After the layer is depressurized, the gas flows to the mined area of the mining layer. Based on the interaction between coal-rock medium deformation and coal-bed gas flow, a mathematical model of solid-gas coupling for double-coal gas overflow is proposed.

The state equation and the continuity equation are used to establish and solve the dynamic model of the unloading gas in the adjacent layer, analyze the over-flow law of the unloading gas in the adjacent layer, and use the long horizontal rock hole in the Yangquan No. 1 Mine. Layer gas drainage work. For the research and application of the solid-gas coupling theory of multi-coal system gas flow, although some progress has been made, due to the complexity of this problem, scholars at home and abroad have not abstracted their universal law from the perspective of gas flow. Establish the corresponding solid-gas coupling theory.

6. The current problems and development direction of gas drainage theory

From the above literature review, although the current gas migration theory in coal and rock masses from coal seam gas seepage law, coal seam gas diffusion theory, coal seam gas seepage-diffusion law, multiphysics, multiphase coal rock gas coupling law and the research on the law of gas flow overflow from coal seam pressure to gas migration in mining fracture zone. Under certain simplifying assumptions, the development has formed a more rigorous theoretical system and played a certain role in the safe production of coal mines. However, due to the migration process of gas in coal and rock mass, it is a very complicated process. Due to various factors, various theories have certain applicable conditions, and most of the research is focused on the coal rock mass before the stress peak. The law of gas migration in the area does not involve the nature of coal mine gas control and mining. Whether it is high-stress soft coal seam, or the coupling law of fluid seepage and coal-rock deformation after coal-rock strata damage or coal-rock mass in the post-stress peak area, the solid mechanics description of seepage skeleton is not complete. Therefore, in the future, the development direction of coal mine gas control and drainage theory should focus on the seepage constitutive relationship of the post-peak coal and rock mass, the distribution and evolution of fractures in the mining rock mass, and then study the migration law of gas in it. For the gas migration law of the mining fracture zone, it is currently limited to the study of gas uplift-diffusion, gas dynamic dispersion, etc., but does not consider the influence of gas pressure on the coal rock skeleton, and the deformation of coal rock mass. The research on the influence of gas pressure and gas

concentration distribution law, that is, the gas seepage field, the gas concentration field and the distribution characteristics of the coal rock mass fissure field are not combined to study the migration law of gas in the mining fracture zone. A large number of on-site practices have proved that the migration law of gas in the fracture zone is quite complicated, including gas dispersion, gas uplift, gas diffusion, gas flow and interaction with coal rock skeleton. The law of gas migration under the combined action of factors is the research focus of gas drainage theory in the future, and it is also the theoretical basis for achieving coal and gas safety.

7. Conclusion

Based on the similar simulation experiments of the distribution of overlying rock mass under the influence of mining, based on the detailed recording of experimental phenomena and experimental data, the migration law of the separation and fracture faults with the mining process and the development of the mining fracture zone are studied. Time and space regularity and distribution characteristics, and quantitative analysis, the following conclusions are drawn:

(1) During the coal seam mining process, the subsidence value of the general upper strata is larger than that of the high-rise overburden. Moreover, the overlying rock strata (except for the fall zone) undergo a continuous dynamic subsidence movement process, and the farther away from the coal seam roof, the more continuous the movement process, and the movement process of the surface point is basically similar, and the maximum sinking amount is basically The upper part is located in the middle of the mining area. On the contrary, the closer the overlying strata are to the coal seam (especially the fall zone), the more irregular the sinking curve is and the maximum sinking value is at the place where the pressure is applied.

(2) The distribution of the separated fractures in the fully mechanized caving process presents a three-stage characteristic: 1 Starting from the open cut, with the continuous advancement of the fully mechanized caving face, the separated fissures will continue to increase, and the separation rate in the middle of the goaf is the largest; After repeated pressures, the fractures in the middle of the goaf tend to compact and the rate of separation is reduced. 3 In the vicinity of the fully mechanized caving face away from the cut, the fractures of the overburden can still be maintained, and the rate of separation is large.

(3) The occurrence and development of overburden fractures are also divided into three stages: 1 before opening the cut to the top of the roof before the initial pressure, the fracture density of the roof rock increases with the advancement of the working face, until the first pressure of the working face , to reach the maximum; 2 the normal mining period of the periodic mine pressure after the initial pressure of the top plate. In this stage, with the fall of the overlying rock, the fracture gap develops to the upper level, but when the working surface advances to a certain distance, the meteorite in the middle of the goaf is re-compacted, and the fracture density is rapidly reduced. 3 Supported by the support at the working face and near the open cut, the density of the fracture distribution of the overburden is still very large.

(4) It is determined by experiments that the width of the first stage fracture development zone A1 is basically equal to the initial pressure step of the fully mechanized caving face, while the width A2 of the fracture zone near the working face changes between the pressure step of 1~2 cycles. At the same time, after 2 to 3 cycles of the pressure step, the density of the fracture of the overburden near the coal wall is greater than the fracture density of the overburden at the cut hole.

(5) The development of overburden fracture and fracture, the development of fractures and the movement of rock formations are not completely synchronized. The development from bottom to top is non-uniform. Generally, the development speed of the fractures is faster than the fracture. Moreover, not every fully mechanized caving cycle has a change in the overburden layer. It is a dynamic change of the separation layer after several cycles, especially when the roof overburden (or the main and sub-critical layers) breaks and falls. This change is very obvious.

(6) The occurrence and development of overburden mining fissures are completely determined by the masonry beam structure formed during the fully mechanized caving mining process and its breaking and instability modes. Generally, the fracture-breaking gap is more developed in the range of 3.1 to 3.5 times of the overburden coal mining, and the upper part is dominated by the layered fissure; in the vicinity of the incision and the working face, the upper overlying fissure is more developed; in the middle of the goaf The fallen rock and the

regular moving belt rock mass compact the overlying rock fissure and extend its shape to the entire three-dimensional space for mining. It is a mining fissure development zone.

(7) In the lower part of the mining overburden (mainly in the development zone of the broken fracture zone), the rock mass expansion coefficient is divided into three zones: 1 before the initial pressure from the open eye to the top plate, the coefficient of expansion is large in this zone; After pressing, the compaction zone in the middle of the goaf is formed, and the coefficient of small expansion is small in this zone; 3, the coefficient of shrinkage is still large near the working face. On the vertical line at the same distance from the working surface, the coefficient of expansion of the rock layer increases between the inner and outer elliptical surfaces, away from the working surface; in the inner elliptical surface and outside the outer ellipse, Keep away from the level of the working surface and gradually decrease.

(8) The coordinate values of the fracture zone and the compaction zone measured by similar simulation experiments, by programming the curve fitting parameters and the fitting equation, the spatial distribution of the mining fracture zone is an elliptical parabolic zone. It is further verified that after the fully mechanized caving of the coal seam, there is a mining fracture elliptical belt in the overburden, and the relationship between its shape and the main key layer is analyzed.

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