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Research Article

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Coal Seam Gas Occurrence and Flow Law Under the Influence of Protective Layer Mining

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Abstract: Underground gas in coal mine mainly comes from coal seam and coal measure strata and is closely related to the origin of coal. There are two kinds of gas occurrence state in coal seam, namely adsorption state and free state. The coal seam gas content actually refers to the sum of adsorbed gas and free gas, and its value is often an important index to evaluate the coal seam gas reserves and whether it has drainage value. The amount of gas content in coal seams mainly depends on the conditions of gas preservation, rather than the amount of gas generation, that is to say, not only depends on the quality of coal, but more importantly depends on the geological conditions of gas storage. According to the current research results, the main factors affecting the coal seam gas content are coal seam gas storage conditions, regional geological structure and mining work. On the other hand, coal seam is composed of pore and fissure structure, gas flow in the pore is mainly diffusion, flow in the fissure system of coal seam belongs to penetration. This paper will explain the law of coal seam gas occurrence and flow and make a simple analysis.

Keywords: gas occurrence; Safety engineering; Coal mining

1.Influential Factors of Coal Seam Gas Occurrence

Faults and fold structures

Geological structure not only controls the formation and evolution of coal-bearing strata, but also plays an important role in the generation, preservation, accumulation and loss of coal seam gas. It is the key geological factor for the formation of coal seam gas occurrence and gas outburst.

Through the study of gas geological law, it is found that the main fault interruption distance is low gas occurrence (low gas content), which indicates that the sealing and preservation ability of gas in this area is poor. The smaller fault distance is mainly high gas occurrence (high gas content), indicating that the sealing and preservation ability of gas is strong. The gas control gas in the axis of the fold syncline is easy to enrich, and the gas content is generally higher than that of the two wings, while the gas control law of the anticline is opposite (the gas content in the axis of the anticline is generally lower than that of the two wings).

The metamorphic degree of coal

The intensity of coalification controls the hydrocarbon generation of coal and the metamorphic degree of coal. The more intense the coalification, the greater the amount of hydrocarbon generation, the higher the metamorphic degree of coal, and vice versa.

The degree of coalification is usually expressed by the degree of metamorphism of coal. When the coalification is large in the process of coal formation, it promotes the formation of a large number of hydrocarbon-generating substances in coal, and the gas content in coal is generally high. At the same time, the increase of coal metamorphism makes the permeability of methane gas decrease, and the gas is easier to gather; the fracture development in the coal is large, the adsorption capacity of the coal to methane increases, and the amount of gas is also larger, which makes the gas content of the coal hydrocarbon generation power higher.

Roof and floor lithology

Surrounding rock of coal seam is another important controlling factor for the occurrence, migration or enrichment of coal seam gas. The permeability of sandstone roof is better, which is conducive to the escape of coal seam gas, and the gas content of coal seam is relatively low. The roof permeability of mudstone and sandy mudstone is poor, which is not conducive to the dissipation of coal seam gas, and the gas content of coal seam is relatively high.

coal seam overlying bedrock thickness

According to the test results of coal seam gas content and the analysis of gas emission data, with the deeper burial depth of coal seam, the longer the distance of gas migration to the surface, the more difficult it is to dissipate, and the gas content of coal seam tends to increase. At the same time, due to the pressure of the coal seam, the increase of the buried depth also makes the permeability decrease, so the thickness of the overlying bedrock has a great influence on the preservation of gas.

2.Coal Seam Gas Flow Law

Causes of flow

Coal mine gas is mainly generated in the metamorphic stage of coal and exists in the coal seam in two states of adsorption and free. Due to the weak gas permeability of coal seams, gas is not easy to disperse in coal seams, so gas exists in coal seam with pressure gas. In the current mining depth of the main gas coalfields in China, the gas pressure is about 10 ~ 40 atmospheric pressures. The air pressure in the roadway space of the mine is 1 atmospheric pressure. The mining work destroys the balance of the original gas pressure and forms a flow field in the coal seam.

This flow from high pressure to low pressure is mostly manifested as gushing, and in special cases, it can also form ejection and outburst. The gas emission of coal surface generally decreases with the increase of exposure time of coal surface. In addition to the natural factors such as geological conditions, gas pressure, permeability and climatic conditions, the gas emission of each production site in the mine is also closely related to the mining factors such as production process, mining method, mining intensity, mine pressure activity, ventilation system and so on. Therefore, the gas emission of the mine is not balanced. In addition to the gas emission of the mining coal seam itself, the adjacent coal seam also emits gas to the mining space after the pressure relief or fracture of the interlayer rock. The emission law is related to the activity of the mine pressure, the properties of the interlayer rock and the method of roof management.

Gas flows in coal seam and surrounding rock

(1) Gas flow in mining coal seam

There are two conditions for the flow of gas in the coal seam: one is to have a certain flow channel, that is, the coal seam must have a certain permeability; the second is that the gas in the coal must have a certain pressure. According to the current research, within a certain range of the original coal seam, the permeability in the coal seam can be basically considered as a fixed value; therefore, it can be considered that the flow state of gas in the original coal seam mainly depends on the gas pressure in the coal body. In the methane zone, the gas pressure in the coal body increases with depth along the inclined direction of the coal seam, and changes little along the strike of the coal seam. Due to the different gas pressure in each location, in the small range of unmined coal seam, if a line is used to connect the points with equal gas pressure and draw the isobaric line of gas pressure, the relatively stable isobaric line of gas pressure is often distributed in the coal seam.

During the mining work in the mine, under normal circumstances, the balance state of the original stress in the coal seam will be destroyed, resulting in the change of the permeability of the coal body, and the balance state of the original gas pressure in the coal seam will be destroyed, forming a gas flow field.

In fact, the gas pressure contours measured in the mine are often not very regular, which is the reason for the uneven distribution of the original gas pressure in the coal seam and the different permeability of the coal seam. In the mine, this kind of gas flow state from high pressure to low pressure is mostly manifested as mine gas emission: in special cases, gas emission and outburst can be formed.

Our actual measurement in the field shows that the permeability of the coal seam is generally very low, and the flow rate of gas in it is also very high. In this case, the gas flow state in the coal seam is basically a laminar flow

motion, that is, the gas flow rate is proportional to the pressure difference, proportional to the permeability of the coal, and conforms to the linear permeability law.

Practice shows that only in the case of a considerable gas flow, turbulent motion may occur in the coal body near the coal wall. The state and quantity of gas emission in coal seam vary with the location.

On the fixed surfaces such as borehole wall, two sides of roadway and coal pillar, the gas emission per unit area generally decreases with the increase of coal wall exposure time. Sometimes, due to the activity of ground pressure, the permeability of coal seam is changed, and the gas emission has the phenomenon of fluctuation. For the moving coal wall, such as the mining face, the gas emission is related to the moving speed of the coal wall. Because the advancing speed of the working face is often uneven, the amount of gas emission is also constantly changing, generally increasing with the increase of the moving speed of the coal wall.

Part of the gas emission in the roadway comes from the working face. The amount of gas emission in this part is related to the production process and mechanical equipment. If the blasting excavation process is adopted, the blasting will cause sudden stress change and coal crushing in front of the working face, which can cause a large amount of gas emission. The other part comes from mined coal, which can cause a sharp change in the gas emission of the roadway. The measured results show that the amount of gas emission increases sharply after blasting, and the amount of gas emission tends to be gentle with the extension of time. Most of the gas emission in the gentle section comes from the coal wall of the roadway. By comparing the average gas emission in each production process with its peak value, it can be seen that when the peak value is much larger than the average value, it can be considered that the gas content of the coal seam is large or the permeability coefficient of the coal seam is low ; on the contrary, if the peak value is close to the average value, it is considered that the coal seam gas content is low or the coal seam permeability coefficient is large. If the total gas emission of roadway is small, the content of coal seam is low; if the total gas emission of roadway is large, and the change is not large, it shows that the gas pressure of coal seam is high and the permeability coefficient is large.

When using the fully mechanized excavation unit to excavate the roadway, because the machine is gradually cutting the coal seam, the coal body breakage caused by the stress change is relatively slow. So the gas emission curve is relatively flat. In the hydraulic tunneling roadway, the water jet cuts the coal seam violently, the tunneling speed is very fast, the gas release in the coal body is fierce, and the peak value of gas emission can reach 10m3 / min.

The gas emission of the mining face is different from that of the heading roadway, only similar to that of the heading face. Its emission is closely related to the production process. The fully mechanized mining unit makes the stress of the coal body in front of the working face in the process of coal mining. The jump change, the faster the cutting speed, the greater the amount of gas emission; similarly, this imbalance is also related to the gas content and permeability coefficient of the coal seam.

(2) Gas flows in adjacent strata and surrounding rock

When there are adjacent coal seams or a large number of unminable coal seams in the strata near the mining coal seam, in general, after the mining of the coal seam, due to the movement of the surrounding rock and the redistribution of the in-situ stress, a large number of cracks are caused in the strata, which can cause a large amount of gas in the coal seam near the roof and floor to flow into the mining space.

After the first roof fall of the working face, it causes the caving fracture and deformation of the coal seam roof strata, which will cause a pressure relief ring near the goaf. In general, some of the adjacent coal seams in the caving area will directly release gas to the goaf, while some will release gas to the goaf through cracks. Although some coal seams relieve pressure, they cannot release gas immediately, but after a period of time, when the rock fracture develops to the coal seam, the gas in the coal body diffuses to the goaf through the fracture.

In general, the range of gas emission in the upper pressure relief deformation area develops with the continuous development of time and space, and stops after reaching a certain degree. The time and amount of gas in the upper adjacent layer at different distances from the mining layer into the mining area are determined by the caving condition of the rock layer at the top of the mining layer, the nature of the interlayer rock, the thickness of the adjacent layer, the gas content and the length of the working face. Its emission is relatively rapid and often occurs after the first caving of the main roof. When there are several upper adjacent layers above the

mining layer, the phenomenon of sudden increase of gas emission will occur many times in the process of working face advancing.

The gas emission of the lower adjacent layer is different from that of the upper adjacent layer. After the working face advances, due to the large area of space in the goaf, under the action of strong ground stress, the stratum below the mining layer, that is, the goaf space, bulges, and its moving distance can reach more than 10mm.In this way, a large number of cracks are formed between the layers, forming the conditions for the gas in the lower strata to diffuse into the goaf. The degree of upward heave of the lower rock layer varies with the distance from the goaf. The amount of upward movement of the roof of the lower adjacent layer is greater than the invitation of the upward movement of the floor rock layer, so that the adjacent layer swells, and its expansion amount can reach several thousandths of its own thickness, which greatly improves the permeability coefficient of the lower adjacent layer. As the adjacent layer contains high-pressure gas, the expansion force and thrust formed by gas pressure will promote the movement of the rock layer and the migration of gas to the goaf. The gas emission from the lower adjacent layer is generally slow, but when the strength of the interlayer rock layer can form a violent bulge, causing the floor to rupture and the gas to erupt suddenly.

Gas flow theory

The theory of coal seam gas flow is a theory that studies the distribution of gas pressure and the change law of gas flow in coal seam, according to the different application scope and conditions. Coal seam gas flow theory has the following.

(1) Linear gas flow theory

The linear gas seepage theory holds that; the gas migration in the coal seam basically conforms to the linear permeability law-Darcy 's law. In 1856, the French hydraulician Darcy summed up the famous Darcy 's law through experiments. This law is an experimental law reflecting the seepage law of water in rock and soil pores. This law shows that the velocity of water through porous media is proportional to the size of the hydraulic gradient and the permeability of the medium. This theory is also applicable to the flow of gas in each layer. Gas is like water, and coal seam pores are like porous media.

(2) Gas permeation-diffusion theory

Gas penetration and diffusion theory; gas movement in coal seam is a mixed flow process including infiltration and diffusion. There is a mutual communication fracture network in the coal seam; along these fracture networks; the free gas flows to the low-pressure working face, and the permeability of the coal body is closely related to the fracture network. At the same time, the gas inside the lump coal desorbs and diffuses to the crack, so the permeability of the gas in the coal seam and the diffusivity of the medium jointly determine the flow of gas.

(3) Nonlinear gas flow theory

The famous fluid mechanics expert EM. Allen pointed out that the Darcy 's law is used to describe the experiment of gas emission from homogeneous solid (coal sample), and the result leads to a conclusion that is inconsistent with the actual observation. From the determination of gas permeability of coal samples by changing pressure difference, Darcy 's law does not conform to the law of gas flow. On the basis of a large number of experimental studies, the power law which is more in line with the basic law of gas flow is proposed.

(4) Coal seam gas flow theory of ground object field effect

The theory holds that the stress field, geothermal field and geoelectric field, and the stress history also have an important influence on the gas flow field, which should be taken into account and the Darcy 's law and the power law should be corrected.

(5) Gas leakage theory of multi-coal seam system

According to the definition of multi-coal seam gas leakage in underground seepage mechanics, such as the determination of the effective protection range of protective layer mining, the prediction of the reasonable hole layout design drainage rate of the underground adjacent layer (goaf) gas drainage project, and the prediction and evaluation of the migration law of coalbed methane between underground multi-gas layers, all can be attributed to the problem of gas leakage in multi-coal seam system. But because of the complexity of the problem. None of them abstracted its universal law from the perspective of coal seam gas leakage and created the theory of gas leakage in multi-coal seam system. Therefore, the application of fluid-rock interaction point of

view to create and develop the coal seam gas coupling model and numerical method, enrich and improve the coal seam gas seepage mechanics, which is the frontier subject of the theoretical research of the subject.

Conclusion

Each kind of coal seam gas flow theory has formed a certain theoretical system under certain simplified assumptions and has played a certain role in coal mine safety production. However, because the gas flow in the coal seam is a very complex process, it is not only related to the structure of the coal but also affected by many factors. At present, coal and gas outburst accidents occur frequently in coal mines in China, and the number of deaths is large, which seriously affects the safety production of coal mines. The law of gas flow is of great significance for preventing coal and gas outburst, improving the gas drainage rate of coal seams and the development and utilization of coalbed methane. Therefore, the theory of coal seam gas flow needs to be further studied.

3.Personal Views

At present, scientific research has made great achievements in the occurrence and flow law of coal seam gas. Most of our scholars have spent a lot of time and energy studying the lessons learned by predecessors. Although they will also go to the actual coal mine working environment to investigate, it is still impossible to avoid the frequent occurrence of coal mine accidents. The reason is that the actual coal seam gas situation and geological conditions are complex and unexpected. Although the current prediction and forecasting technology has been very accurate, some dangers are such sudden occurrences. I think we should pay attention to the safety of underground workers. It is not enough to rely solely on the supervision and management policies of managers. It is not enough to rely solely on the theoretical knowledge of those books. We need to fundamentally reduce the occurrence of accidents. Whenever an accident occurs, the staff under it is the first group to be threatened. We need to make the underground staff deeply aware of the importance of life safety, strengthen the safety knowledge training for miners, and keep them vigilant at all times, pay attention to dangerous sources, and eliminate dangerous hidden dangers. Starting from every little thing of underground work, ensure the safety of every step of operation.

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