

Application Practice of 'One Through Three Prevention' Technology in Gob-side Entry Retaining of 1027 Working Face

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Abstract: As one of the main energy sources in China, it is very important to ensure the safe production of coal. Aiming at the problems of air leakage, gas accumulation, large dust and spontaneous combustion of coal seam in 1027 gob-side entry retaining working face of Jiegou Coal Mine in Anhui Province, the technical measures of "one ventilation and three preventions" are adopted. Through the use of Y-type ventilation system, thin spray sealing technology of gob-side wall and three kinds of fire prevention and extinguishing technology, the safe production of gob-side entry retaining working face is ensured, which provides technical and practical experience for the "one ventilation and three preventions" work during the safe mining period of gob-side entry retaining working face.

Keywords: Retaining roadway along the empty; 'One ventilation and three prevention'; Technical measures; Gas prevention.

1. Introduction

As an important part of China's energy, coal occupies its dominant position. In the past, coal consumption accounted for more than 50% of total energy consumption[1-2]. Gob-side entry retaining mining can alleviate the problems of high production cost, low mining efficiency and tight mining replacement[3-4]. However, due to the gradual complexity of mining conditions, dust and toxic gases will be produced in the production process of roadways, and even gas explosion and natural phenomena will be more serious. If the staff can not guarantee the underground ventilation system, it will threaten the safety of life. Therefore, it is a top priority to solve the difficult problems of ventilation technology, gas control technology, fire and dust prevention and control technology in roadways. Therefore, the implementation of 'one ventilation and three prevention' technology is an important key. In the modern operation of the coal mine industry, through the use of one ventilation and three prevention technologies, it provides technical support for the rapid development and stable operation of coal mine enterprises, creates a safe production environment, and helps the high efficiency of various operational activities in coal mine production[5-7].

2. Engineering Background

The 1027 working face is located in the Jiegou Coal Mine in Anhui Province. The northern part of the 1027 working face is the 1026 working face, the western part is the south wing track roadway of the East No.1 lower mining area, the eastern part is the mine boundary, and the southern part is the 1028 working face. There are two mining roadways in the 1027 working face, including the air roadway and the machine roadway. The air roadway is the gob-side entry retaining of the 1026 working face, with a length of 796 m, and the length of the 1027 working face is 941 m. The coal seam of 1027 working face is 10 coal, which is mainly composed of dark coal and bright coal. The elevation of

working face is 493~558 m. The occurrence of coal seam is relatively stable. The dip angle of coal seam is 5° ~ 23° , with an average of 13° . The structure of coal seam is simple. The thickness of coal seam is 0.6~3.0 m, with an average of 1.6 m. The coal seam belongs to class II spontaneous combustion coal seam. The strike length of working face is 672~688 m, with an average of 680 m. The measured maximum gas pressure of 1027 machine roadway is 0.03 MPa. According to the research results of fire prevention and extinguishing technology for high gas mine and easy natural coal seam mining at home and abroad, combined with the production technology level of Jiegou Coal Mine, the Y-type ventilation system technology of gob-side entry retaining in 1027 working face and the thin spray sealing technology of inorganic flexible material along gob side are put forward by adopting the technical scheme of 'one ventilation and three prevention'. It provides a certain reference for this type of mine.

3. Y-type Ventilation System of Gob-side Entry Retaining

In order to solve the problem of gas accumulation in 1027 working face, Y-type ventilation system is adopted in the working face. Compared with the U-type ventilation, the air volume of the Y-type ventilation working face is larger, the air pressure of the retained roadway section is reduced, and the air leakage in the goaf is reduced, which can effectively improve the upper corner of the mining working face and the gas accumulation problem, and reduce the pressure difference between the mining and the goaf. Therefore, the ventilation of the working face is optimized as a Y-type ventilation system. By advancing the cutting hole and machine roadway of 1028 working face in advance, the air path is formed with the roadway of 1027 working face, forming a two-in and one-return Y-type ventilation system with 1027 two-lane air intake, 1028 cutting hole and machine roadway return air, as shown in Fig.1.

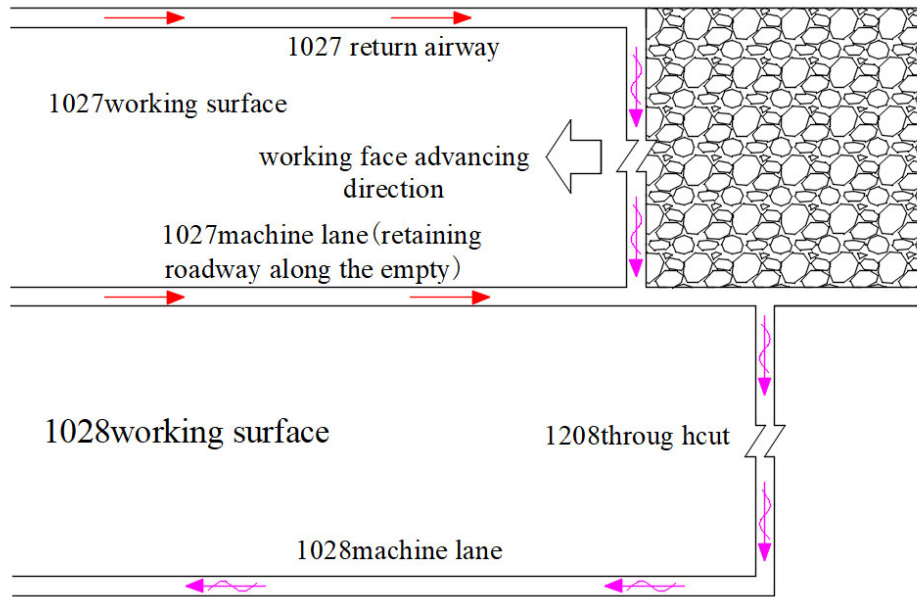


Figure 1. 1027 Y-type ventilation system of gob-side entry retaining

The ventilation lines of the ventilation system are as follows :

Air inlet path one : auxiliary shaft → -425 ~ -500 m east wing track downhill → south wing track roadway of Dongyi 10 lower mining area → 1026 machine roadway → 1027 through hcuit (mining face) → 1027 gob-side entry retaining → 1028 through hcuit → 1028 machine roadway.

Air inlet path two : auxiliary shaft → -425 ~ -500m east wing track downhill → south wing track roadway of Dongyi 10 lower mining area → 1027 machine roadway feed joint roadway → 1027 gob-side entry retaining → 1028 through hcuit → 1028 machine roadway.

Return air path : 1027 through hcuit (mining face) → 1027 gob-side entry retaining → 1028 through hcuit → 1028 machine lane → south wing return air lane of Dongyi (10) lower mining area → -425 ~ -500m east wing return air downhill → -354m east wing return air lane → -354m total return air lane → air shaft.

4. Gob-side Entry Retaining Grouting Sealing Technology

Due to the roof caving rock on the goaf side of the gob-side entry retaining, it is easy to conduct the gas in the goaf and the working face. Therefore, it is necessary to spray the roadway side to achieve the effect of sealing the cracks and preventing the air leakage in the goaf[8]; at the same time, in order to prevent the fracture development caused by the deformation of the roadway side, the sealing effect is affected. The spray material is selected as the silicate modified polyurethane material for spraying and plugging air in coal mine. The material has the characteristics of micro-expansion, high toughness, high flame retardant and certain strength. The material is sprayed onto the surface of coal rock mass by spraying process to achieve the effect of plugging air[9]. The specific technology is as follows :

(1) Temporary closed goaf in dynamic pressure affected zone of gob-side entry retaining

The dynamic pressure affected area of gob-side entry retaining is affected by the mining of working face, and the overburden rock in goaf is not stable. At this time, the roadway adopts the temporary support of unit support, so it is

not suitable to carry out the closed construction of roadway side shotcrete. However, at this time, the collapsed gangue is easy to enter the roadway. In order to prevent the entry of gangue, plastic steel mesh is used to prevent the entry of gangue. At the same time, the air duct cloth is laid to close the goaf. One end of the air duct cloth is laid on the floor of the retained roadway and compacted with scattered coal, and the other end is staggered on the roof of the retained roadway. The U-shaped steel shed is externally pressed on the air duct cloth. The upper end of the U-shaped steel shed is connected with the hanging net bolt, and the lower end is buried in the floor. The spacing of U-shaped steel shed is 500 mm, which prevents the caving gangue from entering the roadway.

(2) Gob-side entry retaining stable area shotcreting closed goaf

The overlying rock activity in the goaf of the stable area of the gob-side entry retaining is stable, and the deformation of the surrounding rock of the gob-side entry is greatly reduced compared with the dynamic pressure affected area. At this time, the polyurethane material spraying and sealing construction of the roadway side is carried out, and the spray thickness is not less than 50 mm. At the same time, the area after the spray is observed regularly. According to the characteristics of mine pressure, it is judged whether it is necessary to carry out re-spraying operation and determine the specific re-spraying thickness.

5. Comprehensive Fire Prevention and Extinguishing Technology of Working Face Mining

Combustion and explosion in coal mine underground operation is a kind of safety accident with great harm and rapid progress. The coal seam of 1027 working face belongs to class II spontaneous combustion coal seam. It is necessary to design the comprehensive fire prevention and extinguishing system of working face and do a good job in the monitoring of spontaneous combustion of coal seam. Once the signs of fire in the working face are found, emergency prevention and control measures should be taken to prevent it before it occurs[10]. The fire prevention and extinguishing system of the working face adopts nitrogen

injection fire prevention and extinguishing technology, inhibitor fire prevention and extinguishing technology and grouting fire prevention and extinguishing technology, among which nitrogen injection fire prevention and extinguishing technology and inhibitor fire prevention and extinguishing technology are mainly used, and grouting fire prevention and extinguishing technology is used as the backup technical scheme of the mine.

5.1. Nitrogen injection fire extinguishing technology

Nitrogen injection can not only play the role of cooling, but also dilute the oxygen concentration, so that the oxygen concentration in the goaf is reduced, because liquid nitrogen can inhibit coal oxidation and reduce the surrounding oxygen concentration after being injected into the goaf. At the same time, nitrogen injection in the closed goaf can also play a certain role in explosion suppression.

(1) Nitrogen injection method

There are two main methods of nitrogen injection (a) Drilling into the goaf and transporting nitrogen to the goaf through drilling to achieve the effect of fire prevention and extinguishing ;(b) Buried pipe in the working face air lane, through the nitrogen injection pipeline to transport nitrogen from the pipeline to the goaf, to achieve the effect of fire prevention and extinguishing.

(2) Calculation of nitrogen injection amount

According to the 'Code for Fire Protection Design of Coal Mines'^[11], the calculation formula of nitrogen injection in mining face is as follows :

$$Q_N = 60Q_0 \frac{C_1 - C_2}{C_N + C_2 - 1}$$

In the formula : Q_N is the nitrogen flow rate (m^3/h) ; Q_0 is Air leakage in oxidation zone of goaf, taking $10\text{m}^3/\text{min}$; C_1 is Original oxygen concentration in oxidation zone of goaf, taking 12%; C_2 is the index of fire prevention and inerting in goaf, taking 7%; C_N is the purity of the injected nitrogen, taking 97%.

According to the above formula, the amount of nitrogen injection is $750\text{m}^3/\text{h}$ in the working face of gob-side entry retaining.

(3) Nitrogen injection method in goaf

According to the roadway layout of 1027 working face, the nitrogen injection pipeline is pre-buried in the 1027 air roadway. Combined with the test results of the three oxidation zones in the goaf, the release position of the nitrogen injection port is determined to be 25 ~ 50 m.

(4) Measures to prevent air leakage and nitrogen leakage into the nitrogen injection area

If the local roof of the working face goaf is suspended, it is easy to cause air leakage and nitrogen leakage in the goaf. Therefore, it is necessary to strengthen the roof caving on the inlet and return air sides of the goaf. Before the working face is moved, the net of the anchor net support is broken in advance, and the bolt of the bolt is unloaded, so that the top rock falls off and the air leakage channel on the inlet and return air sides is blocked. When the roof of the air inlet side of the goaf can not fall down by a large number of steel beams or plate supports, the forced roof caving measures should be taken to force the roof to fall, and the oxygen sensor should be set at the position of 10-15 m away from the wind side of

the working face in the gob-side entry retaining.

(5) Gas monitoring system in nitrogen injection area

The purpose of monitoring is to be able to monitor the gas change components in the intake and return air flow of the working face and the goaf, to understand and master the change law and dynamics of spontaneous combustion in time, so as to take preventive measures in a targeted manner, and to provide a scientific basis for selecting the best nitrogen injection parameters. The gas monitoring in nitrogen injection area is composed of mine safety monitoring system, on-line monitoring system of environmental parameters in goaf and on-site manual detection. It mainly observes gas temperature, O_2 , CH_4 , CO and CO_2 .

5.2. Inhibitor fire extinguishing technology

As long as it is a material that can inhibit the rate of chemical reaction, it can generally be called an inhibitor. The inhibitor makes the coal body inert at low temperature, or enhances the activation energy required for the oxidation of coal, and forms a liquid film on the surface of the coal seam, thus blocking the contact between oxygen and coal body and filling the internal cracks of coal pillar. The inhibitor also has certain water absorption, and the water evaporation absorbs heat and cools down. The water can inhibit the oxidation of coal in the low temperature oxidation stage of coal, so as to prevent the spontaneous combustion of coal.

(1) Inhibitor category

The inhibitors used in coal mines are : water glass, calcium chloride, ammonium chloride and magnesium chloride. When selecting the type of inhibitor, it is necessary to consider not only the effect of the inhibitor, but also the comprehensive consideration of economic and other aspects. Although the water glass has a good inhibition effect, it is generally not used because of its high price. The inhibitor with lower price is calcium hydroxide, and its inhibition effect is better. However, when it is mixed with water, it often solidifies and becomes turbid, and the solid particle size is basically enough to destroy the conveying pump. This kind of turbid liquid is also easy to cause blockage during the conveying process, which is difficult to clean up and affects the progress of the project. In addition, due to its strong alkalinity, it will also cause corrosion to downhole equipment, so it is necessary to increase equipment cost or increase manual maintenance of equipment ; industrial MgCl_2 not only has low cost, but also has good inhibition effect. The market is large and easy to purchase. Because of its weak corrosivity, compared with calcium hydroxide, it reduces the cost of equipment and manual maintenance. Therefore, it is recommended to use industrial MgCl_2 as a mine fire prevention and extinguishing inhibitor.

(2) Calculation of inhibitor spraying amount

The amount of inhibitor sprayed into the mined-out area is calculated according to the following formula[11]:

$$V = Q_y \eta \rho_c LHS$$

In the formula : V is the spraying amount of inhibitor, m^3/d ; Q_y is the amount of liquid used per ton of coal, taking 0.04 m^3 ; η is the coal loss rate of the working face, taking 3%; ρ_c is the density of coal, $1.33\text{t}/\text{m}^3$; L is the length of the working face, taking 190m, H is the mining height of the working face, taking 2.8m; S is the daily progress of the working face, taking 3.6m.

Therefore, the spraying amount of inhibitor in 1027

working face is 3.05m³/d.

5.3. Grouting fire prevention technology

According to a certain proportion, the water and slurry are mixed and stirred evenly to obtain a certain concentration of cement slurry. The slurry is input into the slurry pipeline, and the slurry is transported through the pipeline to the area where the spontaneous combustion danger zone exists. The technology to prevent or extinguish fire is called grouting fire prevention and extinguishing technology. Due to the large amount of residual coal in the goaf, the air leakage is large, and the risk of spontaneous combustion is high. Preventive grouting can make full use of the penetration and adhesion of the slurry to cover the surface of the coal body, so that the coal body can not contact with oxygen, so as to prevent the coal body from being oxidized. At the same time, because there is a certain amount of water in the slurry, on the one hand, it can play a role in cooling, on the other hand, it can inhibit the oxidation of coal body, which is very effective in preventing coal spontaneous combustion. Therefore, the grouting fire prevention and extinguishing system is designed.

(1) Grouting method

In China, according to the different grouting time, it is divided into three grouting methods : pre-mining pre-grouting, grouting with mining and post-mining grouting. Pre-injection before mining : This method is mainly aimed at the coal seam with many old goafs and serious spontaneous combustion of coal seam in the mine field. The coal seam is grouted before mining to prevent spontaneous combustion ; mining with irrigation : this method is mainly in the process of mining, through drilling, buried pipe or direct spraying slurry to the goaf ; post-mining grouting : This kind of method is to grout into the closed area by means of intubation to prevent spontaneous combustion in the goaf after all the working faces are mined and all kinds of closed work are completed. In daily production, the most commonly used is buried pipe grouting. Due to the non-uniformity of goaf diffusion, in order to prevent the slurry from returning from the grouting port to the end or working face support, the pipeline is buried into the goaf for a certain distance. When the grouting operation is carried out, at the same time, it is observed at all times during the grouting process. If the slurry returns to the end or support, the grouting should be stopped immediately, and the grouting can be carried out after the grouting port is buried deeper.

(2) Calculation of grouting amount in working face

The grouting amount of working face is calculated according to the following formula[11]:

$$Q_w = \frac{GWh(\delta + 1)M}{\rho_c HLNt}$$

In the formula, Q_w is the grouting amount of working face, m³/h ; G is the daily coal production of the working face, taking 2000t/d ; W is the grouting width along the direction of the working face, taking 90m ; h is the thickness of slurry covering layer, taking 0.1m ; δ is the reciprocal of soil-water ratio, taking 4 ; M is the slurry production rate, taking 0.91 ; ρ_c is the density of coal, 1.33t / m³ ; H is the mining height of the working face, taking 1.6m ; L is the length of the surface, take 189m ; N is the slurry additive fire extinguishing efficiency factor, taking 1.0 ; t is the grouting time of the well, taking 4h/d.

It can be calculated that the grouting amount of 1027 working face is 50.8 m³/h.

(3) Grouting operation

The 10# coal seam of Luojiogou Coal Mine belongs to class II spontaneous combustion coal seam. The yellow mud grouting system is mainly used to start grouting during the stop mining period of the working face or when the working face advances slowly with abnormal conditions of CO, CO₂, CH₄, O₂, C₂H₄ and other gases. The second is to carry out centralized grouting after closing.

(a) Buried pipe grouting when working face is abnormal

Using the buried pipe grouting method, the grouting pipe is paved in advance along the 1027 air roadway to the goaf, and the depth of the slurry outlet buried in the goaf is 30 m. Under normal production conditions, the grouting system is not grouted. When the advance is slow or the CO concentration in the return air flow rises to more than 24 PPM, the grouting system is started to grout the goaf until the normal production of the working face.

(b) Concentrated grouting after mining closure

After the end of the permanent closure of the working face, a ϕ 108 mm grouting hole is reserved on the closed wall of the working face, and a large amount of slurry is poured into the working face. The slurry volume is calculated according to the filling 20 m goaf, and the spontaneous combustion and closed air leakage of the coal seam in the most spontaneous combustion stop line are prevented. Special personnel inspection should be arranged during grouting. Once the signs of slurry collapse are found, the grouting should be stopped immediately.

6. Conclusion

The technical scheme of Y-type ventilation system for gob-side entry retaining and the technical scheme of inorganic flexible material thin spray sealing for gob-side entry retaining are adopted in 1027 working face of Luojiogou Coal Mine to solve the problems of air leakage, dust and gas accumulation in gob-side entry retaining working face. By calculating the amount of materials required for nitrogen injection fire prevention, inhibitor fire prevention and grouting fire prevention technology, the safety work of " one ventilation and three prevention " during the mining period of working face is ensured, and the corresponding safety accidents are avoided. Finally, it plays a certain reference significance for the comprehensive application of ventilation, dust reduction, gas prevention and fire prevention in gob-side entry retaining working face.

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