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Research on the technology of filling and repeated mining in thick coal seam affected by small mine gob area

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Abstract

Filling repeated mining technology of small coal mines mainly researches on the gob or cavity in the coal seam formed by the mining method of small coal mines. Adopting the means of field exploration, indoor test, the simulation experiment, pumping filling material that is stable in mechanical property and low in price into the gob, it can meet the needs of normal mining and achieves the purpose of mining safety and efficiency. The keys of this technology are detecting, the stability and controlling method of the surrounding rock, management and safe-efficient mining process technology. The gob of small coal mines in B909 working face of Anjialing No.2 underground coal mine affected the advancing of the working face. In view of this situation, the detecting method and solution were researched. The results showed that, combining geophysical exploration and the trinity of detecting, releasing, controlling, a specific location of the gob could be mastered accurately and the harmful factors could be removed. According to the characteristic of recovery, the suitable filling material and scheme were chosen to deal with the gob by grouting. This guaranteed the stability of the surrounding rock and the coal in the period of mining. These methods mentioned above realized the safely and efficiently mining of the coal seam affected by the gob of small coal mines and provided experiences to the coal resource exploitation of similar condition.

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1 Introduction

Since 1980s, the coal enterprises began to carry out diversified economy model in development policy in China. Low recovery ratio such as small coal mines blossomed everywhere. In the 2010~2015 period, the coal

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enterprises were decreased from more than ten thousand to four thousand or so. Plenty of small coal mines were shut down. Because the original small coal mines adopted old-fashioned room and pillar mining method, this led to low ratio of exploration and serious waste of resource. Shallow coal seam in Shanxi, Inner Mongolia, Xinjiang, Gansu was damaged in different degree. It brought a great difficulty to large-scale coal enterprises formatted by integrating the small coal mines and Seriously influenced reservation of the resource that the small coal mines mentioned above belonged to disordered mining, insufficient material and chaotic management^[1]. For example, there are 4 underground mines and 3 open pit mines in China-coal Pingshuo Coal Co., LTD after resource integration. Only recoverable reserve of the coal seam destroyed by small coal mines in underground mines reaches as much as 300 million tons according to statistics. Among them, there are 45.19 million tons of recoverable reserve were destroyed and forced to give up in No.2 mining area of No.2 underground mine. This seriously impacts the length of service. Therefore, how to exploit the coal seam destroyed by small coal mines is a technical difficult problem faced by most of the coal enterprises.

At present, repeated mining in damaged area is still in exploratory stage. Such as, grouting yellow mud into the gob of the small coal mines after drilling in Honghui mine^[3-4], Yanzishan mine^[5] of Datong applied small move face and beforehand support technology, bypassing the destructed area and forming Knife-handle style and fully-mechanized working face; High water material was grouted into the gob in dealing with the damage of the small coal mines In Yunjialing mine of Handan^[6]. The existing repeated mining technology has not been able to form the systematic research result to guide the production practice. An integrated technology is still needed to be found. so, the technology and theory of filling and repeated mining research on specially thick coal seam affected by gob of small coal mines has practical significance and application value.

If the coal seam mentioned above is repeated mined, the following technical problems should be faced^[7-10]:

- (1) Because of the technology material of mining is not clear, the location of the gob is difficult to master.
- (2) For the time is too long, most of the gob contain water and harmful material such as clay sand.
- (3) Harmful gases are accumulated in the gob with the extension of time, such as gas and CO, etc.
- (4) As the surrounding rock has been influenced and yielded by mining, so the roof falling is easy to happen when mining near the gob.
- (5) It brings a lot of difficulties to the recovery of the coal resource destroyed by small coal mines.

How to recovery the coal influenced by the small coal mines on condition that the working face is safe becomes a key technical problem in coal mining. In this paper, the B909 working face Anjialing No.2 underground coal of China-Coal Pingshuo Coal Co., Ltd. was introduced as the engineering practice. The problem was solved by using the patterns of leading putting out, filling, repeated mining.

2 Engineering background

The main mining coal seams in Anjialing No.2 underground mine of China-Coal Pingshuo Coal Co., Ltd. are coal 7, coal 9 and coal 11. The length of B909 working face is 282m and 1592m along tendency. The mining area is 448944m². Coal 9 mined at the working face is black, bulk, basically semi-bright and rich in vitrain. Its thickness is 11.50-14.48m, 13.01m in average. Its seam is steady and dip angle is 1.2 - 4.9° , 2.5 ° on average. It adopt fully mechanized caving mining to mine the overall height in one time. The mechanical production height is 3.3 m. The direct roof is basically sandstone and direct bottom tends to be shale rock.

3 Detecting

3.1 Detecting the coverage of the small coal mines

Before designed, the area destroyed by the small coal mines in working face was fully detected by means of electric method and 3D seismic exploration. The boundary affected by the small coal mines and the unusual water-accumulating area could be delineated^[11-13]. If there was gob in the seam, the electrical property of the corresponding strata and the surrounding rock was different. The gob full of water is with the electrical

characteristic of low resistance and high chargeability. Because of the existence of caving, fracture and layer separation, the surrounding rock was with high resistance and low chargeability characteristic. The bigger deformation was, the greater the resistance was. According to this, boundary can determine water-accumulating gob could be ascertained^[14].

3.2 Drilling for the gob of the small coal mines

In the process of tunneling, the alternate drilling method that was prior to excavation head and around area was used and it drilled the two sides of the roadway for every 140 m. When tunneling, every 4 cycles , 3.2m(0.8m was one cycle), 5 m in length anchor drill pipe was adopted as the added drilling on both sides and the front of the working face to deal with the area that could not be covered.

As No. 2 underground mine was a mine with low gas, water is the biggest trouble to the safety. According to the geophysical exploration and hydrological characteristics, the hydrostatic pressure could be inferred. When the water pressure was high, the upper area of tunneling face was drilled at first, then gradually to the lower area to drill the water holes. Pressure reducing was combined with water drawing off. In the drilling engineering of near the gob of the small coal mines, single-hole and directional drilling along the coal seam drilling was used. The head was always lag behind the end of the hole and no less than 20 m was kept as the advanced distance. The maximum water release and the requirement should be considered before water releasing. The problems of water increasing, drain ability restricting and schedule influencing were basically solved by adding the special drainage system. the secure, controllable, rapid water releasing under high water pressure was realized through combining geophysical exploration and the trinity of detecting, releasing, controlling.

Seven gob and the corresponding scrap tunnels exploited by the method mentioned above as shown in Fig.1.

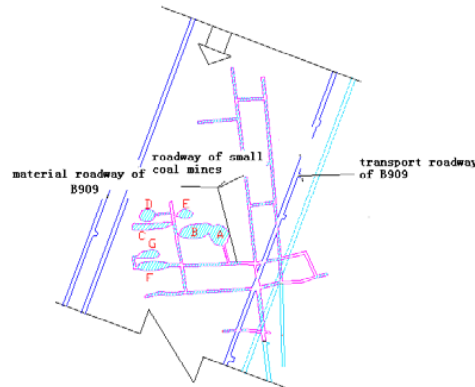


Fig.1 distribution of the small coal mines in B909 working surface

All of the gob were stable and researchers could enter them for surveying. The surrounding rock was in stability, but the strength has been reduced. Once they were affected by mining, the stable balance would be ruined. Roof caving existed in some gob and the fragmented coal could be found in it. As shown in Fig. 2:

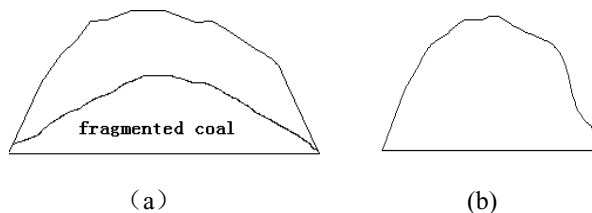


Fig.2 (a) gob with fragmented coal; (b) gob without fragmented coal

As estimated, the volume of the small coal mines was about 15500m³, the area was 63300m². Total quality of the coal affected by the gob of small coal mines was more than 2 million tons.

4 Filling

As the size of the gob was large, it was easy to form a wide range of roof caving affected by mining. This brought risk into the safety of the working face. Filling the whole gob by grouting could solve that problem. Injecting inorganic filling material, the fragmented coal cemented together, strength and integrity were improved^[15]. As the influence of mining, filling material which had support and lateral restraint function interacted with surrounding rock. The system stability was enhanced^[16].

4.1 Choosing the filling material

Traditional filling mining was mainly used in solving the coal under water, building or railway. Filling material was used as permanent underground structure to support overburden strata and control surface subsidence^[17]. Filling material used in dealing with small coal mines would be mined out together with the coal, so it should have the following characteristics:

- (1) The mechanical performance must meet the requirement of the roof supporting, also the blending ratio of strength is easy to adjust.
- (2) Some filling material is in the cutting scope of the coal mining machine, so it should be cut-able.
- (3) Because the material cut down will be mixed with the coal, it should be less hydratable and washable.
- (4) The material should be easy to buy, the cost is within acceptable.

According to the analysis, as the gob was large in size, Ruimi material and foamed cement were chosen as filling material to fill the different gob respectively.

Ruimi material^[18] is a kind of single solid powder. According to the proportion mixed with water, it can be manufactured to be solidified filling material. Its strength is adjustable and easy to adjust, the cemented performance of integrity is good. It is not viscous when cutting and is washable. It is divided into Ruimi 1 and Ruimi 2 according to different performances. This Product has been used in permanent flame proof seal dam, gob side gateway filling support and filling falling region of big volume etc^[19].

Foamed cement is a mixture of gelled material and foaming agent. It has the advantages of light, pump-ability, waterproof, strong absorption capacity of impact energy, making use of industrial waste, low cost. Foamed cement is with the quality of concrete, good adhesiveness. Different intensity of foamed concrete can produced according to the requirement. It is non-toxic, odorless, non-volatile and will not cause harm to human body.

4.2 Carrying out the filling scheme

According to relative position of B406 and B407 working face in coal 4 with gob of small coal mines in coal 9 as shown in Fig. 3. The pumping station is arranged in B406 auxiliary roadway. The injected holes was drilled in B407 auxiliary roadway and B406 transport roadway according to the relative position between the gob and the roadway.

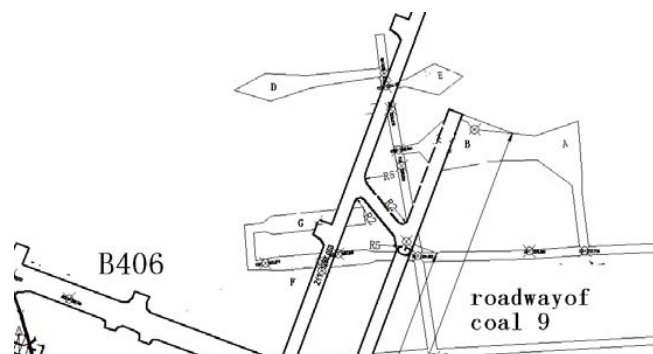


Fig.3 relationship between the gob and the above

1. Arranging the filling system

(1) Sealing off the gob

Ruimi material and foamed cement are liquid mixture. Before solidified, liquid particles are tiny and with good liquidity. So, the gob must be sealed off when filling to prevent loss and environment disruption cause by the liquid.

Brick and mortar were used in building the airtight wall with 0.5m in width. The place close to the gob, with good condition of roadway, convenient for drilling was chosen for building the airtight wall. Groove with depth of 0.2-0.3m was dug before building the airtight for stability. The places with large part of the crack were sealed off when spraying the concrete on the outboard of the wall to the liquid from leaking.

(2) Drilling construction

Drilling construction for gob A and B was carried out in transport roadway of B407 and gob C,D,E,F and G was in transport roadway of B406. The hole was drilled by mine geological drill was from roadway above the gob to acme along the downward or ramp. Holes between the gob and the roadway were barrier-free.

2. Grouting construction

In the period of grouting, the underground room was as large as to decorate the grouting equipment and filling material and was convenient for transportation. The underground room was large enough for operating. As shown in Fig. 4.

Foaming cement was used in gob D without fragmented coal. The rest gob adopted Ruimi material.

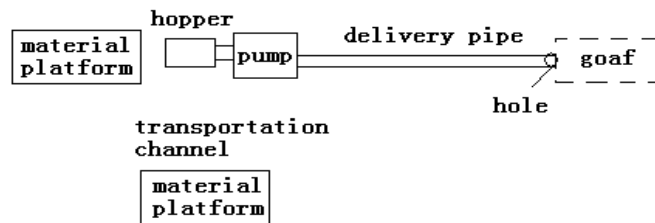


Fig.4 distribution of the grouting system

Holes on top of the fragmented coal were first grouted using Ruimi 1. Ruimi 2 was injected into the gob the fill the height of coal cutting 3.3m, until Ruimi 1 completely permeated into the fragmented coal. Roof of the working face ranged 4m was filled with Ruimi 1 and other space was Ruimi 2. Filling low-strength material in upper space could not only lower the cost, but also increase the compression. The material provided cushion when regenerated roof bore great force from the main roof and maintained stability of regenerated roof.

5 Analysis on repeated mining in filling area

In certain geological condition, mining height is one of most important factors affecting the damage of overburden strata^[20-21]. The greater the mining height is, the larger the space mined is. This must increase destructiveness of the overburden strata. Therefore, non-caving mining method was applied when the working face was 20m away from the gob. During mining, the ground pressure did not appear abnormal. Working resistance of the supports did not change with the mining method of filling repeated mining and normal mining. As shown in Fig. 5

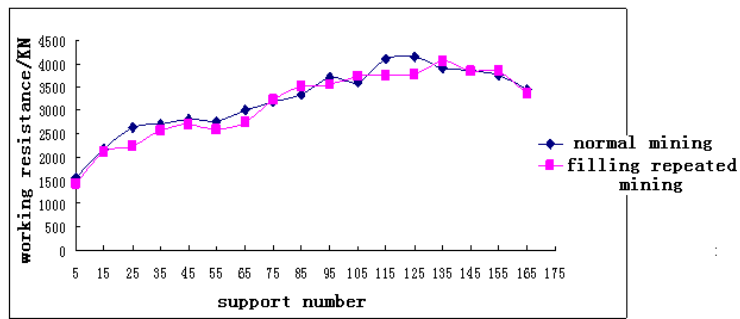


Fig.5 comparative analysis on the support



Fig.6 (a)permeability of the filling material; (b)stability of the roof ; (c)effect of coal cutting

Filling repeated mining construction in B909 working face achieved good result. As shown in Fig. 6.

(1) Filling material had good permeability, which could improve the strength and integrity of the fragmented coal. This created condition for safety production.

(2) Massive broken and roof falling did not appear when filling material worked as artificial roof. That is to say the strength and stability met the needs of mining.

(3) During cutting, the coal wall was in good stability and did not appear rib spalling. This provided condition for smoothly progressing.

(4) More than 2 million tons coal were raised and creating considerable economic benefit.

6 Conclusion

Filling repeated mining was a success in dealing with specially thick coal seam destroy by gob of small coal mines in Pingshuo mine. This owned to the scientific decision of leaders, careful and scientific research and organization skill of the construction site. The following conclusions were obtained through the research:

(1)Combining geophysical exploration and the trinity of detecting, releasing, controlling, the specific location of the gob could be mastered accurately and the harmful factors could be removed.

(2)Filling materials were chosen according to the characteristic of surrounding rock of the gob. The filling system was arranged reasonably and the result was good. The mixed liquid leaked into the fragmented coal and the surrounding rock. Roof falling and rib spalling did not appear during mining. The recovery work in the area of gob affected by the small coal mines in B909 working face was smooth.

(3)More than 2 million tons coal were raised because of filling repeated mining in B909 working face, so dealing with the gob by grouting and filling had the advantages of little effect to the working face, high economic benefit, simple process, safe and reliable. It realized safely and efficiently mining

(4)The success filling repeated mining in B909 working face provided experiences to the coal resource exploitation of similar condition in Shanxi, Inner Mongolia and Gansu, etc.

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