Research on Continuous Miner Mining with Backfilling Technology under High Geostress and Complex Conditions

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Abstract. Aiming at the mining seam with large burial depth, strong geostress, large deformation of the roadway, and fast deformation speed, in order to efficiently recover the coal resources at the working face and effectively protect the surface buildings. Based on analyse of the law of the appearance of the underground roadway pressure in the relevant working face, combined with continuous miner mining technology and equipment technical characteristics, this paper proposes to use a combination of continuous miner mining technology and backfilling technology to mine under high geostress geological conditions. And optimize the mining process parameters according to the field application. The results show that the continuous mining miner with backfilling method can achieve the efficient recovery of coal resources under high geostress and complex conditions.

1 Introduction

In recent years, continuous miner mining technology has been successfully promoted in mining areas where the pressure of the mine is not obvious, and in combination with fluid backfilling methods such as paste filling under good geological conditions also has been applied. The resource recovery rate and control effect are well, and good field test results have been obtained [1]. At present, many scholars have conducted in-depth research on the deformation mechanism and control technology of surrounding rock in roadways under high geostress geological conditions [2,3], and the control theory and technology of backfill mining [4,5]. The mining seam of the 2-4 working face of Xingdong Mine has large burial depth, large ground stress, large deformation of the roadway, and fast deformation speed. In order to effectively protect the surface buildings and obtain good mining results, based on the analysis of the appearance pressure of the roadway in this working face, and the control principle of the deformation mechanism of the surrounding rock, this paper has studied the mining technology combining continuous miner mining and backfilling under high geostress geological conditions, and achieved good results.

2 Geological conditions and pressure characteristics

2.1 Geological conditions

Xingdong Mine mainly mines 2 # coal seam, which is

located in the lower part of the Shanxi Formation. It is the main recoverable coal seam in the minefield. The coal seam has stable layers and thicknesses, and can be mined in the entire area of the minefield. The coal seam thickness is 2.65 ~ 5.48m, with an average thickness of 4.29m.

The lithology of the roof is mainly siltstone and medium-fine-grained sandstone, partially mudstone and silty mudstone, and the lithology of the floor is mainly siltstone, followed by medium-fine sandstone, which is moderately stable. From the contour of the coal seam floor, the local maximum angle of coal seam inclination is about 16 °, and the minimum is about 5 °. Coal seam inclination is not affected by geological changes. The hydrological and geological structure of the mine is relatively complicated, with faults developed, and the mine is a low-gas mine.

2.2 Characteristics of the occurrence of mining pressure in the working face

The downhole elevation of the 2-4 working face is from -730 to -820m, which belongs to the deep mining area. The original rock stress will theoretically reach 20 MPa, and there are many faults distributed around the working face, which have different tendencies and drops.

After the surface displacement observation of the main entry roadway and the auxiliary transport roadway for more than one year, the deformation of the surrounding rocks is shown in Figures 1 and 2.

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Fig.1. Surface displacement of main entry roadway and auxiliary transport roadway

Fig.2. Surrounding rock deformation speed

As can be seen from the above figure, the convergence speed of the two sides of the main entry roadway and roof sinking speed are 0.6mm/d and 0.3mm/d respectively. The sinking speed is small and the deformation continuity is strong. Finally, the two sides converge and the roof sink cumulatively were 221mm and 114mm, respectively. And the average floor heave deformation reaches 0.36mm/d, which is greater than the roof sinking speed, and the cumulative floor heave volume is greater than the roof sinking accumulation, indicating that the roadway is mainly affected by horizontal structural stress.

The convergence speed of the two sides and roof sinking speed of the main entry roadway are 0.28 mm/d and 0.17 mm/d, respectively. The accumulated deformation amounts are 109mm and 67.4mm, respectively.

The deformation speed of the bottom heave is 0.43mm/d, which is greater than the deformation speed of the roof and the two sides, and the amount of the bottom heave is greater than the convergence and the sinking of the roof. The deformation time has a certain duration, which indicates that the roadway is also affected by the horizontal tectonic stress. It also shows that the cross section of the roadway increases and the stability of the surrounding rock decreases. Judging from the deformation of the roadway in the working face, the main entry roadway (5.0m) is 1000mm wider than the

auxiliary transport roadway (4.0m), and the cumulative deformation of the two sides and the roof sinking amount are nearly doubled, indicating that the section of the roadway is one of the main factors affecting the amount of deformation [6].

3 Adaptability analysis of continuous miner mining with backfilling

3.1 Analysis of the influence of the deformation of the rib of the roadway and the roof & floor

After more than one year of observation on the two roadway, although the two sides of the roadway are relatively broken (partially like a fist-sized coal block), the maximum approach distance of the two sides is 221mm and the roof sinking is 114 mm, and the roadway deformation is not serious. It shows that the current support strength and support density have played a good role in supporting surrounding rocks.

If the continuous miner mining with backfilling method is adopted, in the roadway layout system, the service time of the main entry roadway and the auxiliary transport roadway is short, about half a year. The surrounding rock control experience and the deformation rule of the two roadways in this working face will be provide a solid foundation and guarantee for roadway excavation[7], coal mining and backfilling after this time. Although the cross section of the mining branch roadway is slightly larger (recommended > 5.2m), its service period is only about one week, and the control of surrounding rocks is relatively easy to achieved.

3.2 Control of triangle roof in depillaring

Continuous miner carries out coal mining in branch roads through splitting. Generally, single-wing or double-wing oblique cutting is carried out at a certain angle which is greater than 45 degrees normally. Due to the limitation of the cross section of the roadway, the continuous miner needs to wipe the corner several times generally before it can splitting at the specified angle. This will increase the triangular area of the mining gate, which will make it difficult to control the surrounding rock of the roof and easily cause a roof fall accident.

Therefore, in the design of the branch roadway, the section of the branch roadway should be enlarged as much as possible to ensure that the continuous miner can make splitting at a larger angle and reduce triangular area of the mining gate. At the same time, in addition to the normal support, the design of the support of the roadway will also consider the use of ladder beams or I-beams at the mining gate and reinforcement of the anchor cables (Figure 3) to increase the stability of the roof in the triangular area, so as to ensure the safe mining of the continuous miner. Furthermore, the backfilling can also be completed under controllable conditions, so that the filling material has a timely supporting effect on the roadway and gob roof, and relieves the supporting pressure effectively.

Fig.3. Support method of branch roadway

4 Mining equipment and technology

4.1 Major equipment

According to the geological conditions and target requirements, one continuous miner been used to complete the coal cutting and loading procedures during the roadway excavation and mining. A feeder crusher was selected to achieve coal crushing and reloading of the coal, and one shuttle car be used to complete the coal transportation between the continuous miner and the crusher. Two self-moving supports were used to complete the temporary support of the roof of the working face. The support method of the roadway excavation process mainly adopted artificial support.

4.2 Mining & Backfilling technology

The characteristics of the comprehensive driving, mining and filling technology for continuous miner mining with backfilling are mainly the alternate roadway driving (mining) and parallel mining and backfilling operations. When the roof conditions are good, the branch roadway can be alternately driven by double lanes. If the roof conditions are poor, the single roadway method is considered. This paper takes the double roadway driving as an example to illustrate the process.

4.2.1 Driving process

First, the main roadway (main transport entry) is excavated. After the main roadway has been excavated, the branch roadway excavation process can be started by

continuous miner. When the required driving distance is reached, the supporting procedures can be done. Continuous miner exits the branch roadway and go to driving the second branch, and when the specified distance is reached, the supporting operation can be performed. During the roadway driving, by controlling the floor angle of the roadway, the purpose of using a shuttle car to transport coal is achieved. This process is repeated to driving the remaining roadways. The detail is shown in Figure 4.

Fig.4. Schematic diagram of branch roadway driving

4.2.2. Mining & backfilling process

After the first branch road has finished recovering the coal pillars, the continuous miner exits the first roadway and picks up the second roadway coal pillars. At this time, the first roadway can be closed by the wall and filled.

When the mining of the second branch roadway is completed, the backfilling operation can be carried out. At this time, the filling material of the first branch has reached the predetermined solidification time [8]. The continuous miner can then enter the next branch driving and splitting process. The process is shown in Figure 5.

Fig.5. Mining and backfilling process diagram

4.2.3. Implementation of mining process

Considering the influence of conditions such as high ground pressure and complex geological structure, the mining and backfilling process is carried out in stages. In the early stage, the single-wing layout of the branch roadway was adopted. With the continuous accumulation of on-site practical experience, workers have mastered the use of equipment and the control laws of the surrounding rock of the working face.

Under the mature conditions, based on field observations, combined with the theoretical calculation of the roof collapse distance, the design scheme can be optimized, then the mining method can transition from single-wing mining to double-wing mining or other optimization methods to improve mining and filling efficiency.

5 Field application

Since the working face adopts continuous miner with backfilling mining technology, the average monthly output is 65,000 tons based on the daily amount of roadway excavation is 20-35m and the splitting volume is 8-10. The working face recovery rate is 83%. Twenty days after the backfilling of the mining area was completed, there was no significant subsidence on the

ground surface corresponding to the gob, and the surface buildings were intact, which verified the support of the filling body to the mined-out area. During the mining, no compressive impact occurred, and the deformation of the roadway was effectively controlled to ensure the safe production of the working face.

6 Conclusion

The mining technology of continuous miner with paste filling can meet the requirements of mine production under high geostress geological conditions.

Analysis of the adaptability of continuous miner with backfilling mining to geological conditions and reasonable selection of major mining equipment and process parameters are the prerequisites for achieving safe and efficient production at the working face.

It is the first time that the continuous miner mining technology has been applied in deep mine under high geostress conditions. The application of the combination of this technology and backfilling technology will be a huge technological innovation. It have provided a new development direction for the coal mining system which under the building& railway.

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