Stress and Deformation Characteristics of Coal Seam of Island Mining Face in Upward Mining

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Abstract. Based on the geological conditions of 31706 island working face, its stress distribution law of various stages, deformation of coal seam and the stability of coal pillars has been analyzed by using the probability integral and UDEC software. The results shows that maximum deformation of coal seam of 31706 working face is 1689 mm and fluctuation angle is small, which will not affect the normal mining of coal seam; the 31706 working face is located in the area of pressure relief, the elastic potential energy accumulated in the coal could released and it could reduce the danger degree of pressure bump; at the same time, according to the laws of stress distribution of coal pillar, the roadway is located in the area of pressure relief when the width of the coal pillar is 16m. According to the study results, the 31706 working face has been mined successfully, which has a certain guiding significance on the similar conditions of working faces.

Introduction

Due to various reasons, some minable seams are deserted above gob in many existing production mining area. Today the contradiction that resources are irrefragable and demand is unlimited has been increasingly sharp, and it is very necessary that how to extract and use these minable seam. However, quite a number of coal seam requires ascending mining when recycling[1]. The mining of bottom coal seam caused the structure of a range of upper part of strata, even the coal seam generating movement damage when ascending mining[2-3]. A number of researches on overlying strata movement rule and the feasibility of mining under different upward mining conditions has been made[4-8]. However, most of these researches were made in the single wall mining or room and pillar mining, rarely involving the analysis on the upward mining aspects of the island working face.

In view of the upward mining of island working face, systematic research has been made by this paper by means of theoretical analysis, numerical simulation calculation, probability integral method and so forth, ensuring the safety mining of working face.

General Situation of Island Working Face

The average thickness of 31700 coal mining area coal seam in Huancheng coal mine is 2.57 meters and 31706 working face was unexploited when mining from the November of 1996 to the December of 2002.

31706 working face is near the east boundary of Huancheng coal mine, on whose left is 31704 working face extracted in the January of 2003 and on whose right is 31708 working face extracted in the September of 2000. 32706 working face that is under 31706 working face has been extracted in the October of 2003. Therefore, the mining of adjacent working face has made 31706 island working face which needs upward mining.
Deformation and Destruction Analysis of The Upper Coal Seam

The probability integral method and the numerical simulation software called UDEC has been used to analyze the coal’s deformation and destruction of 31706 working face in order to predict the subsidence, deformation and destruction of the coal seam under the influence of mining.

Probability Integral Method Analysis

MSDFVS software is used to analyze which is developed on the basis of the general geographic information platform MapInfo based on probability integral method and has independent intellectual property rights.

The calculation is based on the most dangerous situation that the recovery rate is 100% and the thickness of the design extraction is 2.2 m. Rock movement parameters are shown in table 1 and the calculation results are shown in fig.3.

<table>
<thead>
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<th>Symbol</th>
<th>( tg\beta )</th>
<th>( q )</th>
<th>( b )</th>
<th>( S/H )</th>
<th>( K )</th>
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<td>0.80</td>
<td>0.3</td>
<td>0.1</td>
<td>0.5</td>
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By fig.2, we can find that, after mining the lower coal seam, the maximum subsidence values of the transportation lane, the track lane and the cut location of 31706 working face are 1678 millimeters, 1075 millimeters and 1689 millimeters respectively. The coal floor of them has some ups and downs, and the largest the maximum undulation angles are 0.42°, 0.32° and 2.76° respectively, which has less damage to the coal seam. Although there are some ups and downs, the roadway driving and the normal mining of the working face isn’t affected.

Numerical Simulation Analysis

1) Model Establishment and Parameters Selection

According to the geological survey of 31706 working face, numerical analysis model, whose size is 550 meters by 170 meters, is established. The lower coal seam mining height is designed as 2.2 meters, while the upper is designed as 2.62 meters, as shown in figure 3.

Model’s horizontal direction is fixed on both sides of the border and the vertical direction is free boundary, while bottom vertical direction is constraint and horizontal direction is free. The uniformly distributed load is exerted above the model. And Rock average density is defined as 25KN/m3. Meanwhile, according to the buried depth of coal seam, the calculation result of the load is 7.5MPa.
2) Coal Seam Occurrence Stability Analysis
During the lower coal seam mining, a bend deformation on the roof occurs, producing many cracks. Along with working face advancing, the cracks are developed towards the top, leading to the occurrence of upper coal seam deformation damage. However, the whole structure of the coal seam in the working face is good, and the occurrence doesn’t affect the drivage and extraction of the working face, as shown in figure 4 and figure 5.

3) Coal Seam Settlement Analysis
The subsidence of the coal seam in 31706 working face was affected by the lower mining, and the largest subsidence displacement is 1580 millimeters. The results of numerical simulation and the calculation by the probability integral method are basically identical, as shown in figure 6.

Bearing Stress Distribution of Coal Pillar
Working face order is that mining 31704 and 31708 working face which are on both sides of the 31706 working face first, then 32704 and 32706 working face which are at the bottom and the final mining is 31706 working face.

Seen from the stress arch evolution figure, we can find that after working out the both sides of faces, the stress will be redistributed, as the saddle in the upper face, and it will produce stress concentration about 10 meters to the coal wall on both sides of the working face. When the lower face has been worked out, the stress of the coal wall on both sides will be significantly reduced and the island working face will be located in the internal pressure relief area. The mining of the bottom working face has the effect of unloading, making the accumulation of elastic potential energy on
island working face released and reducing the danger level of percussive ground pressure on island working face.

![Diagram of Stress Arch Evolution](image)

**Fig. 7 Stress Arch Evolution Diagram**

### The Stability of Coal Pillars

According to the characteristics of coal pillar lateral stress distribution, the width of chain pillar should be designed as 16 meters in the upper gateway tunneling of 31706 working face and the lower gateway is very far from the 31708 working face. Therefore, the stability of chain pillar in the upper gateway should be only analyzed. Fractional stoping should be on the numerical analysis model established with UDEC software. In the course of 31706 working face, the roof pressure distribution curve of different mining stages and the plastic distinguish of coal Pillars has been shown in figure 8 and figure 9.

Figure 9 shows that if the both sides of 31706 working face is worked out, the peak stress of coal wall on the left side will be 23.34 MPa and the distance between the peak position and the coal wall will be 10 meters. Then the peak stress of the mining at the bottom reduced to 16.71 MPa, but the stress at the right side of the coal wall will be increased and still less than the peak stress of the both sides that has been worked out.

![Stress Diagram in Different Recovery Stages](image)

**Fig. 8 Stress Diagram in Different Recovery Stages of Working Face**

![Plastic Distinguish of Coal Pillars](image)

**Fig. 9 Plastic Distinguish of Coal Pillars**

As can be seen from the figure 10, the width of coal Pillars plastic area on the gob side is 6.5 meters, while the other side is 5.8 meters. And the width of the elastic area that exists in the coal pillars is 3.7 meters.

This showed that the plastic damage will appear on both sides of the coal pillars when the working face has been worked out. However, the elastic area that exists in the coal pillars results in an incomplete collapse. As the coal pillars have the plastic damage, grouting reinforcement will be used in the course of mining in order to ensure the stability of coal pillars and prevent the upper and lower goaf water from flooding in the working face.

### Conclusion

1) The probability integral method and numerical simulation shows that the coal’s maximum displacement of 31706 working face is 1689 millimeters and the maximum undulation angles in the
upward and downward entries and the open-off cut is 0.42°, 0.32° and 2.76° respectively, which are pretty small. And it doesn’t affect the normal mining of working face.

2) If the bottom and the both sides of 31706 working face has been worked out, the stress on both sides of the coal wall in the working face will be significantly reduced. That the stress exists in the internal pressure relief area has made the accumulation of elastic potential energy on island working face released and reduced the danger level of percussive ground pressure on island working face.

3) Designing a 16-meter chain pillar will make plastic damage on both sides of the coal pillars. However, the elastic area exists in the central and overall collapse of coal pillars won’t occur. According to the stress distribution of coal pillars, we can find that if the roadway is located in the low stress zone of the edge of the coal, the possibility of ground pressure will be greatly reduced and the roadway arrangement will be reasonable.

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References


