Research on top coal caving technique in steep and extra-thick coal seam

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Abstract

Reasonable caving method is an important guarantee of realizing high-yield and high-efficient of the working face. Based on the specific conditions of the 2637 working face in Zhaogezhuang Mine, compared extraction rates under different top coal caving technology with field tests and similar material simulation, adopted the multi-turns interval caving method and the 0.8m top coal caving interval, and got the best sublevel height of top coal in steep seam of Zhaogezhuang Mine is 9m. The result shows that the loss of top coal caving could be controlled under 15.4%, and the mining rate of the coal mining face reached at 84.68%.

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Keywords: Top coal caving mode; Similar material simulation; Top coal caving interval; Extraction-caving ratio; Top coal caving rate

Compared with common longwall mining faces, top coal caving faces are added a top coal caving process. In general, more than half of the coal is mined by the top coal caving process\textsuperscript{[1]}. Therefore, it is necessary to determine the relations between mining and top coal caving from the time and space in design of mining technology. Top coal caving technique has effects on not only the mining rate and refuse content, but also the top coal caving speed, the completion of the normal circulation and the

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realization of high yield and high efficiency in working face \cite{2,3}. Different coal seams and mining conditions should be rational determined the top coal caving technique, to reduce the top coal caving process cycle time and improve the recovery rate, which is the important guarantee of high yield and high efficiency of the working face.

1. General situation of the working face

The 2637 top coal caving face is located in the 6th cross-cut of the 12th level in Zhaogezhuan Mine. The elevation of the face is from -892.2m to -987.5m. The coal seam is stable and simple, with thickness of 8.58m to 14.27m, 10.54m on average, and angle of 44° to 72°, 51° on average. The length of mining district along strike and dip is 360m and 120m. The cut deep of the shearer is 0.8m.

2. Determination of top coal caving parameters

Top coal caving parameters mainly include top coal caving mode and top coal caving interval.

2.1. Top coal caving mode

Currently, top coal caving mode mainly include single-turn order coal caving, multi-turn order coal caving, single-turn interval coal caving, multi-turn interval coal caving, and so on \cite{6,7}.

Based on the specific conditions of the 2637 working face in Zhaogezhuan Mine, adopted the multi-turn interval coal caving mode through experiments, whose recovery ratio was 3% to 5% higher than single-turn order coal caving. Practical operations are as follows: Number the supports with 1#, # 2 and # 3… in turn along the direction of working face. First, release 1/3 to 1/2 of top coal according to the odd numbers 1#, 3#, 5#…, then, release 1/3 to 1/2 of top coal according to the even numbers 2#, 4#, 6#…, repeat two or three rounds to put the top coal out.

2.2. Top coal caving interval

The top coal caving interval will directly affect the recovery efficiency and the recovery rate of the working face, see Fig.1.
Both preventing gangue in mined-out area to flow into the drawing opening and avoiding sublevel gangue influx the drawing opening are needed, while the mining face is caving the top coal. If the top coal caving interval is oversized, the sublevel gangue would get drawing opening earlier than the gangue in mined-out area, which would force the drawing opening to shut down, as a result, the coal loss from back of conveyor will be added, see Fig.1.(a). On the opposite, if top coal caving interval is undersized, see Fig.1.(c), the gangue in mined-out area would get drawing opening earlier than the sublevel gangue, then part of top coal would be blocked in mined-out area. Top coal caving interval is reasonable when the gangue in mined-out area and the sublevel gangue reach the drawing opening at the same time, see Fig.1.(b), the loss rate of top coal becomes smallest.

Use the similar material simulation test to fix reasonable top coal caving interval. Top coal caving interval is divided into three groups: 0.8m (one cut by one drawing), 1.6m (two cuts by one drawing) and 2.4m (three cuts by one drawing). Simultaneously, test the top-coal recovery and refuse rate in simulation test. As shown in Table.1.

<table>
<thead>
<tr>
<th>Top coal caving interval</th>
<th>0.8m(one cut by one drawing)</th>
<th>1.6m(two cuts by one drawing)</th>
<th>2.4m(three cuts by one drawing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top coal caving interval loss (%)</td>
<td>15.4</td>
<td>19.6</td>
<td>22.6</td>
</tr>
<tr>
<td>Coal loss behind the supports (%)</td>
<td>2.5</td>
<td>2.1</td>
<td>5.5</td>
</tr>
<tr>
<td>Top coal loss (%)</td>
<td>17.9</td>
<td>21.7</td>
<td>28.1</td>
</tr>
<tr>
<td>Refuse content rate (%)</td>
<td>5.1</td>
<td>4.4</td>
<td>3.6</td>
</tr>
<tr>
<td>Top coal caving rate (%)</td>
<td>82.1</td>
<td>78.3</td>
<td>71.9</td>
</tr>
<tr>
<td>Face mining rate (%)</td>
<td>84.68</td>
<td>81.64</td>
<td>76.52</td>
</tr>
</tbody>
</table>

It is evident from the table that in the three styles of caving interval, 0.8m (one cut by one drawing) is the best caving interval, which has the highest face mining rate (84.68%), slightly higher of gangue rate of top coal (5.1%), see Fig.2; 2.4m(three cuts by one drawing) is the worst style, whose face mining rate is 8% lower than the style of 0.8m, see Fig.3; the mining rate and gangue rate of top coal of the style of 1.6m(two cuts by one drawing) is between 0.8m and 2.4m, so the style of 1.6m has not its advantages, see Fig.4. So according to the results of the similar material simulation, the best caving interval is 0.8m (one cut by one drawing), whose face mining rate is the highest, and the gangue rate of top coal is slightly 0.7%~1.5% higher than 1.6m(two cuts by one drawing), 2.4m(three cuts by one drawing).
3. The extraction-caving ratio and top coal caving rate

According to the result of similar material simulation, there is some regular pattern between the top-coal caving height and top-coal caving rate. Assume all the other factors are constant, gradually decrease extraction-caving ratio, at first, the thicker the top-coal, the higher the top-coal caving rate. When the extraction-caving ratio is between 1:2 and 1:3.5, there’s no obvious difference in the top-coal caving rate, as shown in the table 3. However if the extraction-caving ratio is lower than 1:3.5, the top-coal caving rate will decrease with the rise of extraction-caving ratio. It means that when the top-coal is thick enough, the top-coal caving rate will decrease instead of increase, with the rise of top-coal thickness. Consequently there’s an optimal sublevel height of top-coal area to the horizontal slicing method adopted longwall with top-coal caving mining in steep seam of Zhaogezhuang Mine. Now the cutting height of the
face is between 2.2m and 2.4m, as calculated, the best sublevel height of top-coal should be between 7m and 10m.

Table 2 Analysis of top coal caving rate in simulation of different sublevel heights

<table>
<thead>
<tr>
<th>Sublevel height (m)</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining height(m)</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>Extraction-caving ratio</td>
<td>1:2.04</td>
<td>1:2.48</td>
<td>1:2.9</td>
<td>1:3.35</td>
<td>1:3.78</td>
</tr>
<tr>
<td>Top coal caving height(m)</td>
<td>4.7</td>
<td>5.7</td>
<td>6.7</td>
<td>7.7</td>
<td>8.7</td>
</tr>
<tr>
<td>Top coal caving interval(m)</td>
<td>0.8</td>
<td>1.6</td>
<td>0.8</td>
<td>1.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Top coal caving rate (%)</td>
<td>83.96</td>
<td>80.52</td>
<td>84.25</td>
<td>80.78</td>
<td>84.68</td>
</tr>
</tbody>
</table>

In order to improve the top coal caving rate, the sublevel height should not be too small, the top coal caving rate is highest when the extraction-caving ratio is 1:3. Through the laboratory top coal caving process test, while the sublevel height is 9m and the top coal caving interval is 0.8m, the face has a higher mining rate and lower gangue rate, and the extraction-caving ratio is 1:2.9, which could satisfy the relevant provisions of the coal mine safety rules.

4. Conclusions

(1) Got through the field observation and laboratory top coal caving process test, the release of the top coal was not continuity in space and time, which made the top coal loss inevitable. According to the result of the similar material simulation, the loss of top coal caving could be controlled under 15.4%.

(2) Got the reasonable parameters of the 2637 top coal caving face through as follows: the top coal caving interval is 0.8m, the extraction-caving ratio is 1:2.9, the best sublevel height of top coal is about 9m. The mining rate of the coal mining face could reach at 84.68% with these parameters.

References