Discussions on Some Security Mining problems of Fully-Mechanized Top Coal Mining in “Three Soft” Large Inclined Angle Working Face

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Abstract

This paper studies insecure factors of fully-mechanized top coal mining in “three soft” large inclined angle working face, which have impacted the normal generation badly, including rib spalling, roof fall and equipment slide, etc. Based on engineering practice of Du-Jiacun 1201 working face, the theory model of coal wall and supports force are analyzed, and protective measures are also put forward. Findings of the study provide technical support for coal mining efficiently and securely, and reference for the similar geological conditions.

Keywords: “three soft”; large inclined angle; fully-mechanized mining; safety production

As a well-proven method in our coal industry, fully-mechanized top coal mining has its unique superiority, including high yield and efficiency, safe production. However, rib spalling, roof fall and equipment slide take place in “three soft” large inclined angle fully-mechanized top coal mining working face frequently, because of the soft coal seam, immediate roof and floor, and lager angle\cite{1-4}. All the adverse conditions can not be conducive to safe and efficient productivity, the study about safe mining is therefore tremendously significant.

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1 Geological condition

The 1201 working face is located in the horizontal of +1200, 2\textsuperscript{nd} coal seam is the main active mine, the thickness is 4.0~10.0m, with average 7.13m. The angle of the coal seam is 31~48\degree, hardness factor $f=0.1$, and with 460m long, 146m inclined width. As shown in table 1 is the roof and floor lithologic characters.

### Tab.1. Roof and floor lithologic characters

<table>
<thead>
<tr>
<th>strata</th>
<th>lithology</th>
<th>Thickness(m)</th>
<th>rock character</th>
</tr>
</thead>
<tbody>
<tr>
<td>basic roof</td>
<td>medium sandstone</td>
<td>3.6~10.2</td>
<td>It is consist of light gray medium sandstone mainly, calcium or argillaceous binder, fissure development, hardness factor $f=6.31$.</td>
</tr>
<tr>
<td>Immediate roof siltstone</td>
<td>5.0~6.0</td>
<td>It is gray, argillaceous or clayey deposits in strata, including layer, broken easily, hardness factor $f=6.31$.</td>
<td></td>
</tr>
<tr>
<td>Immediate floor siltstone</td>
<td>0.1~0.2</td>
<td>It is light gray, turn to be bigger after absorption of water.</td>
<td></td>
</tr>
<tr>
<td>Immediate floor siltstone</td>
<td>2.0~2.3</td>
<td>It contains siltstone mainly, mix 1~3 layers thin seam.</td>
<td></td>
</tr>
<tr>
<td>floor</td>
<td>medium sandstone</td>
<td>12.0~16.5</td>
<td>It is consist of light gray medium sandstone mainly, degree of consolidation differently.</td>
</tr>
</tbody>
</table>

2 Technical measures of soft seam mining

The hardness factor of Du-Jiacun coal mine 1201 working face is only 0.1. Coal wall rib spalling and the top coal broken off often occur, that affect the production efficiency, people and equipment’s safety.

After the working face of fully-mechanized top coal mining excavation, the coal wall next to the goaf is free, being two-directional stress condition, so the force model can be seam as a plane strain problem. As shown in Figure 1. Because of the soft top coal mixed with joints and fissures, meanwhile the pressure from overlying rock formation, the top coal will be broken easily. It usually makes the top empty, causing security issues.

![Fig.1. Force analysis model of coal wall](image)

Soft coal seam mining supports selection on the 1201 working face is adopted with the following measures:

1. Strengthen the supports ability. Improve the working force and early supports resistance reasonablly, can effectively reduce the tensile stress influence at the coal mining face ahead, ease of coal mining face collapsed.

2. The supports adopt adjustable beam and intensive help agencies, to support the roof and wall timely and effectively after coal mining machine cutting coal, preventing collapsed because of the deformation and stress state changes.
(3) Supports structure strengthened seal to prevent leakage coal and empty top. The whole top beam and the side guard board structure are used to fully enclosed top-coal; using side guard board to seal between the beam side guard board of the seal.

In the soft top-coal mining face, once the supports instability, during in "drop-move-rise"—the process of walking, to maintain the supports and top-cola’s stable, we need to take the following measures:

(1) Moving frame wipe under pressure. The control system adopts the quick-moving valve, first, wipe move group operation action valve, then operation drop column action, in order to ensure the valve top beam brush the top bracket move frame.

(2) Discharging pressure brush the top rack. Move to the individual frame difficult supports, at the same time of unloading, the operation supports carry bottom jack valve, make supports not drop from top beam, and raise the base beam, so as to achieve the purpose of moving supports

3 The measures of supports to adapt to the soft bottom

Soft immediate roof is favorable for top coal mining, immediate roof collapse fully and in time can be very good filling goaf, meanwhile improve the recovery of top-coal mining. But Soft bottom can make face supports and scraper conveyors appear the firm phenomenon, the measures are:

(1) The floor is carbonaceous mudstone in Du-Jiacun mine, soft, about 200mm thick, can be recovered through the coal winning machine, make the supports on the hard floor directly, prevent the supports subsidence and the equipment instability.

(2) During the supports design, make the supports stresses position reasonable, and increase the act floor area, try to minimize bottom pressure, prevent floor tip plunging into the floor.

(3) The supports are run-up by the neighbour. When moving the Supports, it should be up front base, reduce the specific pressure, clear up the float coal and speed up the speed.

4 Control measures to prevent slippery falling of large tilt angle face equipment

There has appeared a phenomenon of large scope rib spalling, and equipment slide, in Du Jiacun 1201 working face, through statistical analysis, we know that the phenomenon happens are basically when supports decline in open roof off, so the process of moving the supports is the key to prevent slippery fall.

4.1 The study about technology of preventing supports falling

As shown in figure 2, in the working face of large angle fully mechanized top-coal caving, supports self-respect G and floor force N is in balance, when supports work normally. When the supports suffer under the force action point wide of the supports edges, it may lead to overturn \(^{[5-8]}\). When under limit equilibrium, according to torque limit equilibrium conditions, floor reaction force N acting on the O office, at this point there:

\[
G \cdot \sin \alpha \cdot H - G \cdot \cos \alpha \cdot B/2 = 0
\]

then, \(\alpha = \arctan \frac{B}{2H}\) \((1)\)

The height of gravitational centre H and the width B of the supports are calculated by 1500mm and 1300mm, thought formula (2) we can get the limit dip of supports \(\alpha\) is 24.4°. Consider the safety factor, when the working face’s dip is bigger than 20°, the supports will fall.
The seam dip of 1201 working face is average 33°, which is far beyond the limit. Combining the level of sub-level caving with tilt open-off cut coal caving, using open-off cut tilt—arc transition—level of non-linear pseudo-oblique layout. As shown in figure 3. The way not only reduces the actual face angle, and the arcs to the upper bracket play in restricting the dumping down.

In addition, the supports also added anti-fall device
(1) The side guard plate jack and thrusters spring push the top beam close to each other, ensuring that there is no gap between the top beam frames, and always maintain sufficient righting force to prevent the bookshelf.
(2) Between adjacent beams in the roof frame, transfer frame jack is increased. When supports falling occur, the jack will adjust the supports’ position, take the supports roof of the adjacent supports as the pivot. As shown in Figure 4.
4.2 Technology research of anti-slip supports

In the working face with large angle, supports don’t fall down in the condition that decline force less than friction force, namely:

\[ G \cdot \sin \alpha < \mu \cdot G \cdot \cos \alpha \]  \hspace{1cm} (3)

Take friction coefficient \( \mu \) of the stand base and the bottom as 0.3, thought formula (3) calculating the limit angle of downfall we can get 18.6 °. In general, when the face angle is greater than 15 °, it is necessary to take anti-slip measures. For coal face of 1201 with average angle 33 °, adopted the following measures to avoid supports down:

(1) Make face non-linear pseudo-helical arrangement, reduce the actual angle.
(2) The clearance between the passage rod and the base is controlled in 15~20mm (single side), the gap remains the same, control conveyor decline.
(3) Supports passage rod and conveyor is linked, and therefore prevent the scraper conveyor decline. Field use, you can control over the order to adjust the conveyor transport position.
(4) Set anti-slip jack between the adjacent stand base, have the supports with early supports force as a fulcrum, adjust the position of the adjacent supports.

(5) Set anti-slip device between the conveyor and supports, a group of every five, when transporting conveyor, by controlling the slip jack action, affecting conveyor up and down.
5 Conclusions

The paper combined work face 1201 in Du-Jiacun Mine, aimed at large angle "three soft" caving face with special geological conditions as soft coal, soft top and bottom, established force model of coal face wall and supports, and analyzed factors of insecurity, proposed improvement capacity of supports, strengthen the top beam tightness, using telescopic beam to help care institutions, widening the width of frame, non-linear pseudo-helical arrangement of the face, plus anti-slip devices and other control measures. By applying above measures in 1201 "three soft" caving face with large angle, properly put an end spalling rib, risk (leakage) top, equipment subsidence, down (sliding) racks, and effectively ensure the safe and efficient production.

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