The Geometrical and Geomechanical Characteristics of Sublevel Caving

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ABSTRACT: During recent years, great attention has been given to high-productivity methods such as sublevel caving. This method accounts for 25% of the coal mined in the Jiu Valley. This paper deals with the geometrical elements of the mining method depending on the geomechanical characteristics of the coal. A comparison is also made between the high-productivity method and other mining methods, which shows that productivity is ten times higher with the high-productivity method than with the classical methods.

1 INTRODUCTION

The Jiu Valley is the greatest coal basin in Romania, and is a tectonic depression 50 km long with an area of 137 km². The mining technologies used in this area are very different because of the very hard conditions and a great depth of working.

Researchers have focused their attention on designing and implementing high-productivity mining methods in the coal industry such as coal and surrounding rocks caving and sublevel caving.

The efficiency of mining activity is a problem which should preoccupy the specialists in the field. The market economy enables competition mechanisms and requests low prices and high quality raw-material production.

Taking into account the opportunity of mining the deep coal-deposits in the Jiu Valley effectively, it is necessary to choose and use high-productivity mining methods. This can be achieved by considering the specific geological and mining conditions and by geomechanical characterization based on a profound study of the coal and surrounding rocks.

The method ensures a considerable reduction in the amount of first mining and coal face work as well as higher labor productivity and output.

The significant parameters related to geometric and geomechanical features of the method are the roof coal height and caving step.

The roof coal height is calculated according to the type of coal face support.
When the face support is rigid, then the height of the roof coal is computed with the Equation 1.

\[ H_b = 2,12 \left( \frac{1}{\sqrt{0.75 - \tan \xi}} \right) \]  

(1)

where: \( \xi \) = face width; \( \xi \) = coal caving angle in the roof coal.

In cases where the support has a subsiding bearing, the computation Equation 2 is used for the height of the roof coal.

\[ H_b = 1,72 \left( \frac{1}{0.75 - \frac{1}{1 - \frac{3 \xi}{\lambda K}}} \right) \cdot \tan \xi \]  

(2)

where \( K \) - support rigidity; \( E \) - coal elasticity module; and \( I \) - inertia moment of the roof coal.

If the support constitutes an active bearing, then the roof coal height can be determined by Equation 3.

\[ H_b = 1,6 \sqrt{x \cdot \tan \xi - \tan \xi} \]  

(3)

The value of the caving step, \( x \), of the roof coal can be calculated using Equation 4.

\[ x = \frac{L \cdot \tan \xi}{2} \]  

(4)

3 THE PARAMETERS OF THE MINING METHOD

The main parameters of the method are:

- the seam thickness: \( h = 20-60 \) m;
- seam dip on the strike: \( \alpha = 4^\circ-7^\circ \);
- face height: \( h^* = 3 \) m;
- roof coal height: \( H_b = 15-20 \) m;
- working face length: \( L_o = 40-60 \) m;
- mining panel length: \( L_p = 100-300 \) m;
- face advancing-step (web width): \( x = 0.63 \) m;
- coal dislocation from the roof coal is carried by natural caving, drilling blasting, or by water jet under pressure;
- roof control is achieved by complete caving of the roof rocks.

In order to help coal mining, it is necessary to achieve a certain plane of rupture and sliding of coal, all along the face. This plane is achieved artificially, by drilling and blasting.

The working face technology phases, after the caving plane achievement, present the following succession:

- cutting off the coal from the face, using explosives;
- hoisting the cantilever bars and roof lagging;
- evacuating the mined coal and installing the roof bars with hydraulic props;
- moving (advancing or flitting) the conveyor and controlling the roof along the working face. The roof control is achieved by pulling the last row of props and roof so that roof blocks of about one bar length are allowed to cave;
- evacuation of coal from the roof coal. This is made through the eyes of die lagging steel mesh. The spacing of the evacuating eyes is one meter along the and about 0.5 meter lower then the working face roof.

When compared to other frequently used mining methods, the technical economic indicators obtained are clearly superior, as shown in Table 1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Indicator</th>
<th>Longwall</th>
<th>Shortwall</th>
<th>Room</th>
<th>Sublevel</th>
<th>Caving</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wood consumption ( m/1000 ) t</td>
<td>45-50</td>
<td>8-17</td>
<td>17</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td>2</td>
<td>Timber consumption ( m^2/1000 ) t</td>
<td>12-18</td>
<td>2-7</td>
<td>3</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>3</td>
<td>Explosives ( kg/1000 )</td>
<td>160-220</td>
<td>280-350</td>
<td>200-250</td>
<td>50-100</td>
<td>20-50</td>
</tr>
<tr>
<td>4</td>
<td>Blasting caps ( pieces/1000 )</td>
<td>580-800</td>
<td>750-850</td>
<td>700-1000</td>
<td>100-300</td>
<td>50-150</td>
</tr>
<tr>
<td>5</td>
<td>Wire metallic ( kg/1000 ) t</td>
<td>500-1200</td>
<td>1550-2600</td>
<td>1500-3000</td>
<td>800-1000</td>
<td>500-700</td>
</tr>
<tr>
<td>6</td>
<td>Slice output ( t/day )</td>
<td>70</td>
<td>90-100</td>
<td>150-200</td>
<td>150-200</td>
<td>250-300</td>
</tr>
<tr>
<td>7</td>
<td>Coal roof output ( t/day )</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>600</td>
<td>800</td>
</tr>
<tr>
<td>8</td>
<td>Overall output ( t/day )</td>
<td>70</td>
<td>90-100</td>
<td>150-200</td>
<td>750-800</td>
<td>1050-1100</td>
</tr>
<tr>
<td>9</td>
<td>Number of workers</td>
<td>16</td>
<td>18</td>
<td>18</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>Productivity ( /man )</td>
<td>4.37</td>
<td>5</td>
<td>8.3-11</td>
<td>30-32</td>
<td>42-44</td>
</tr>
</tbody>
</table>

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4 MEASURES AND CONCLUSIONS

In conclusion, the results obtained during the testing period at the mining plants justify the general use of the mining method.

- It is noted that with sublevel caving methods, labour productivity is 3 to 10 times greater than with classical methods. Wood and timber consumption decreases 4 to 25 times with direct bearing on the first cost.
- The volume of first mining is 50 % lower with the proposed mining methods than with the classical methods, while the prime cost per ton of mined-out coal ton is three times lower.
- It should be noted that if the coal face technology is not maintained adequately, coal losses may increase and there is a greater danger of fires occurring.

In order to reduce the danger of fires breaking out, the following measures should be taken:
- the worked-out space should be treated with thermo-power station ashes in a mixture with antipyrogenic substances or chemical foam;
- sealing dams should be built to seal off fires in the access working to the face;
- fire prevention by local inertization with nitrogen;
- gas samples should be taken from the mined-out area for the purpose of monitoring the content of the following gases: carbon monoxide, carbon dioxide, methane, etc.;
- correlation of the technological parameters of the mining method: face length, coal roof height, advance rate.

REFERENCES

Goldan, T. 1999 Optimizarea parametrelor metodelor de exploatare a straturilor groase cu inclinare mare in vederea reducerea perelor de autoaparare a carbunelelor. Doctoral Thesis. Pelisor University

