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Rational cutting height for large cutting height fully mechanized top-coal caving

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ABSTRACT

Large cutting height fully mechanized top-coal caving is a new mining method that improves recovery ratio and single-pass production. It also allows safe and efficient mining. A rational cutting height is one key parameter of this technique. Numerical simulation and a granular-media model experiment were used to analyze the effect of cutting height on the rock pressure of a fully mechanized top-coal caving work face. The recovery ratio was also studied. As the cutting height increases the top-coal thickness is reduced. Changing the ratio of cutting to drawing height intensifies the face pressure and the top-coal shattering. A maximum cutting height exists under a given set of conditions due to issues with surrounding rock-mass control. An increase in cutting height makes the top-coal cave better and the recovery ratio when drawing top-coal is then improved. A method of adjusting the face rock pressure is presented. Changing the cutting to drawing height ratio is the technique used to control face rock pressure. The recovery ratio when cutting coal exceeds that when caving top-coal so the face recovery ratio may be improved by over sizing the cutting height and increasing the top-coal drawing ratio. An optimum ratio of cutting to drawing height exists that maximizes the face recovery ratio. A rational cutting height is determined by comprehensively considering the surrounding rock-mass control and the recovery ratio. At the same time increasing the cutting height can improve single pass mining during fully mechanized top-coal caving.

1. Introduction

Using a cutting height greater than 3.5 m during top-coal fully mechanized caving creates conditions for safely and efficiently mining thick and extra thick seams. The advantages of large cutting height, fully mechanized top-coal caving (Fig. 1) are:

(1) Improved caving characteristics.
(2) The use of high-powered coal cutters and front and rear conveyors.
(3) An increase in the number of drawing ports and a shorter process time for drawing.
(4) Increased ventilation sectional area and reduced air resistance, which helps dilute coal gas in the drawing port and at the upper corner of the working face.
(5) Shorter cycle time at the working face and improved advance rates.
(6) Improved recovery ratios and productivity. Therefore, this is a new path for fully mechanized top-coal caving that will improve the recovery ratio and productivity and will achieve safe and efficient mining.

Stability control at the tip-to-face area and support equipment for large cutting height fully mechanized caving have been much improved after extensive theoretical and practical research [1–6]. This technique has now made very important breakthroughs in cutting height, cutting angle, and hardness of the coal seam, etc. For example, in December 2009, a fully mechanized working face number 22303 of the Bulianta Coal Mine, Shendong, China, the World's first 7 m cutting height, fully mechanized working face was put into production. The maximum oblique angle of the seam is about 25° for this device. Given an extremely soft and thick seam this working face achieved a 5 m cutting height by using stepped cutting technology [7]. These techniques were tested in the Xinglongzhuang Coal Mine in 2006 and since then studies have been done related to rock pressure and the flow of coal gangue [8,9]. Today it is being promoted in a number of mines and has been applied to soft and thick seams successfully [10].

The height increase necessary for this technique causes the stability of the wall and the tip-to-face roof to degrade relative to

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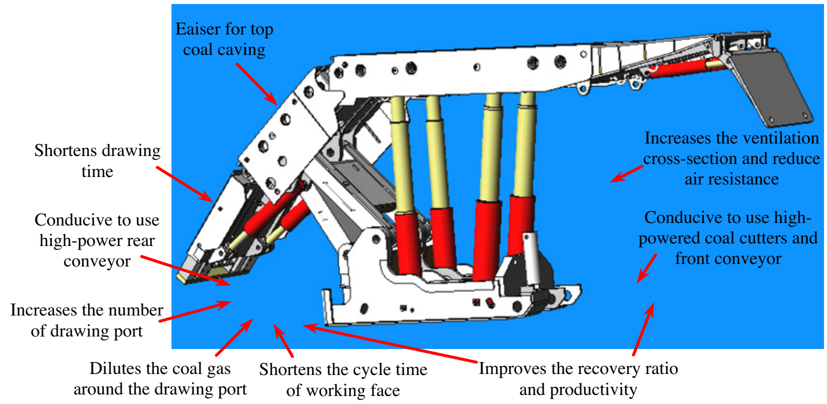

Fig. 1. Important aspects of large cutting height fully mechanized mining with sublevel caving.

a general cutting height fully mechanized top-coal caving method [11–17]. In a given seam the drawing height decreases in proportion to the increase in cutting height. The cutting recovery ratio is larger than the top-coal drawing ratio, which makes the recovery ratio of a large cutting height working face larger than normal. But is the larger cutting height better from the standpoint of increasing the recovery ratio at the face?

At the same time, stability control requirements of the rock surrounding the working face limits the maximum cutting height. Therefore, it is necessary to determine a rational cutting height for fully mechanized top-coal caving.

2. Ratio of cutting height to drawing height: the impact on mining pressure of fully mechanized top-coal caving

2.1. Simulation model

The numerical calculation model was founded with UDEC (Universal Distinct Element Code) software. This model is related to working face number 1308 of the Xinglongzhuang Coal Mine. The model was designed on the principle that it should include the key overlying strata and that the left and right edges should be more than one working-face-width from the wall. The height of the model is 49 m. The strike range is 250 m with a 60 m stump on each side while the advancing distance of the working face was 130 m. Table 1 gives the physical and mechanical properties of working face number 1308. Joint characteristics and a Mohr-Coulomb constitutive model are also included.

The upper boundary of the model is a stress boundary where the self-gravity of the overlying strata is given as

$$q = \sum \gamma h = 13.5\ \text{MPa}$$

The lower boundary can move in the *x* direction but the *y* direction is a fixed hinge bearing, that is to say

$$v = 0$$

On both sides the model has coal rocks. These are simplified as a displacement boundary that allows movement in the *y* direction while the *x* direction acts as a fixed hinge bearing, that is to say

$$u = 0$$

The effect of cutting to drawing height ratio on stope pressure for the same thickness coal seam was analyzed by two kinds of model (Fig. 2).

Model 1: The machine cutting height is 2.5 m, the top-coal thickness is 6.0 m.
Model 2: The machine cutting height is 4.0 m, the top-coal thickness is 4.5 m.

The model predicts changes in the front abutment pressure within 190–250 m of the mining horizon of Seam 3. A simulated monitoring point was also used to monitor sloughing of the wall at 190 m in the vicinity of the coal wall.

2.2. Analysis of simulation results

For an identical coal seam thickness increasing the machine cutting height reduces the top-coal thickness. The increase in the top-coal breaking-caving space and increased roof activity increase the top-coal breaking angle. The displacement increases after the top coal caves. Fragmentation of the top coal is also smaller and the mining-induced rock mass structure shifts up. The axis dimension of pressure arch induced by mining in the overlying strata augments, and the arch springing ahead wall forwards, namely the peak of abutment pressure forwards.

And if the machine cutting height increases from 2.5 m to 4.0 m, the width of the plastic zone at the front of the wall increases from 16 m to 20 m (Fig. 3). Therefore, for a given coal seam thickness the size of the plastic zone depends on changes in machine cutting height and adjustment of the cutting to drawing height ratio.

Table 1
Mechanical parameters of coal and strata for the UDEC simulation.

Lithology		Thickness (m)	Elastic modulus (MPa)	Cohesion (MPa)	Inner friction angle (°)	Density (kg/m)	Poisson ratio
Rock	Medium-sandstone	20.0	12	2.8	29	2.65	0.27
	Medium-sandstone/siltstone	11.5	30	5	30	2.70	0.25
	Siltstone	3.0	12	2.8	29	2.65	0.27
	$3^{\#}$ Coal seam	8.5	4	1.5	27	1.40	0.30
	Siltstone	7.0	12	2.8	29	2.65	0.27
Joint	True joint		18	5	15		0.20
	False joint		18	0	10		0.20