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DETERMINATION OF OPTIMAL BLOCK LENGTH ALONG THE STRIKE TO PROVIDE SAFETY AND EFFICIENCY WHEN EXTRACTING MEDIUM-THICK INCLINED COAL SEAMS USING ROOM-AND-PILLAR METHOD IN QUANG NINH COAL BASIN

Abstract. An analysis of appropriateness of room-and-pillar method for extracting medium-thick inclined coal seams in Quang Ninh Coal Basin taking into account existing mining and geological conditions was carried out. Corresponding foreign experience of applying room-and-pillar method was considered in relation to the mines of Vietnam. Process flow sheet of first mining and extraction of medium-thick inclined coal seams by room-and-pillar method in complicated mining and geological conditions was developed, and optimal block length along the strike to provide the production safety and efficiency was determined.

Keywords: coal basin, Quang Ninh, expansion, medium-thick, inclined coal seams, room-and-pillar method, block, Uong Bi Mine, mining.

Based on the analysis of advanced methods for extraction of flat and inclined coal seams of medium thickness used at coal mines in countries with developed mining industry, one can conclude that to date no efficient modern flow sheets, as well as facilities for extracting coal and face supporting in case of inclined coal seams of medium thickness were developed. Low efficiency of the available flow sheets is due to the lack of scientifically sound design and engineering solutions for extraction of such coal seams in complicated geological and mining conditions.

In leading mining countries, such as Australia, South Africa, the United States, despite of widespread use of longwall mining methods, room-and-pillar methods in the overall pattern of underground mining occupy more than 40 % [1]. About 65 % of the USA production belong room-and-pillar method, and 92.5 % in South Africa. Such active application of the room-and-pillar mining method in USA and South Africa is due to lower initial costs for purchase of mining equipment in comparison with corresponding equipment for longwall mining, as well as high mobility of the room-and-pillar mining facilities [2].

Currently in Russia, as well as in other coal mining countries, the main line of high-performance coal deposit mining is applying longwall mining methods with the use of mechanized complexes equipped with mobile hydraulic support (hydraulic transport). However, the field of application of such mechanized complexes with longwall faces is considerably limited by mining and geological conditions, and their high effectiveness is achieved under favorable conditions only. In other cases, depending on complicated mining and geological/structural conditions, complicated configuration of mining areas, constrained along the strike and down dip, room-and-pillar method (and other less common methods) seems to be more efficient [3–7].

According to historical data, large share of coal reserves (within 67 %) in the "Quang Ninh" coal basin is located in zones of dislocations, where coal seams are limited in length along the strike that encourages applying room-and-pillar mining method [8]. The main advantage of this method is its adaptability to complicated mining and geological conditions of coal seam extraction and short seams along the strike, when longwall mining method application provides low performance.

In recent years, scientific research has been carried out at mines of Vietnam on introduction of room-and-pillar mining method with coal blast-hole blasting, which finds growing application in mines of the Quang Ninh coal basin. The methods advantages consist in low initial costs and low prime cost of coal in comparison with the longwall methods. The main disadvantage of the room-and-pillar method using coal blast-hole blasting with rib pillars is large losses of coal in the pillars, which sometimes reach 30–40 % [9–11].

At the Uong Bi Mine, pilot commercial tests of room-and-pillar mining method for extracting seam 8 were carried. Within the minefield, coal seam 8 is ruptured by numerous faults, the number and amplitude of which increases with depth. The seam thickness ranges 1.2–6.22 m, the average thickness is 3.5 m, the seam dip angle is 30–45°, and, in some areas, it reaches 50°. The coal seam includes interlayers (partings) of clay shale and splits into separate members [12].

Development of a block in the room-and-pillar method begins with tunneling drifts and preparing chutes. The distance between the drifts is determined by the height of level and ranges 60–70 m. From the conveyor drift at the block boundary, parallel inclined workings (diagonal chutes) are raised at angle of 30° spaced at intervals of 60 m, which correspond to the length of the future room. Along the strike, the field of limited length (190 m) is divided into three blocks of 60 m long each. For airing the chutes and room, as well as delivery of materials and equipment, the chutes are connected by cross heading. The preparation flow sheet and description of application of the room-and-pillar method are presented in Fig. 1 and and Fig. 2

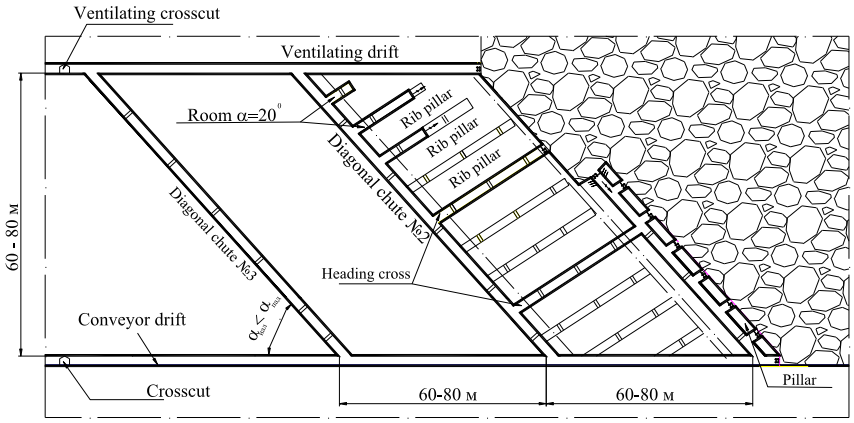

Fig. 1. Flow sheet for preparation work using room-and-pillar method

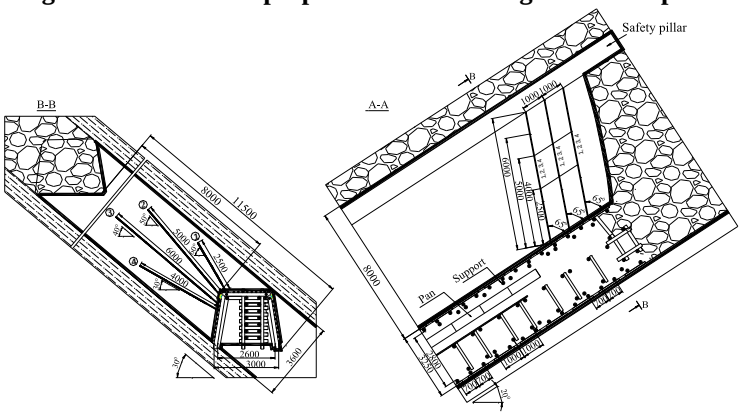

Fig. 2. Description of room-and-pillar method application

For applying room-and-pillar mining method, which is being tested in the mines of the Quang Ninh coal basin, drifts and chutes are equipped with trapeziform wooden support.

Within the block, extracting coal seam is carried out from the block boundary to the coal chute in descending order. The room width is 4–5 m and the length ranges 60–70 m. The rooms are inclined at angle of 20° for facilitating coal transport through the enameled pans, and rib pillar 8 m wide is kept (protective coal pillar) to prevent rock collapse into the face. In case of simultaneous extraction in rooms between two rib pillars, it is necessary to keep at least 15 m of pillar between them.

For coal transportation to the chutes, enameled pans are used. Blasted coal goes through the enameled pans to the chute and further to conveyor drift and then to haulage crosscut up to the surface. When chutes and diagonal room are used, ventilation is provided by the fans of local airing.

The optimum block length along the strike (distance between the chutes along the strike) is determined on the basis of optimizing preparation work and extraction of coal. Preparation of a new block should be coordinated with extraction works to ensure uninterrupted overall mining activities. The optimum distance between the chutes along the strike is determined by the following equation:

$$\frac{\gamma \cdot \eta \cdot b \cdot m \cdot (L_c \cdot \cos\beta - a)}{Q} + t_1 = \frac{L_c \cdot \cos\beta}{v} + t_2. \quad (1)$$

After conversion, we obtain expressions for determining the distance between the chutes:

$$L_c = \frac{\frac{\gamma \cdot \eta \cdot b \cdot m \cdot a}{Q} + t_2 - t_1}{\frac{\gamma \cdot \eta \cdot b \cdot m \cdot \cos\beta}{Q} - \frac{\cos\beta}{v}}, \quad (2)$$

where: z is commercial reserves of the block, tons; γ is the coal density, t/m^3; η is the extraction ratio; m is the seam thickness; b is the rib pillar width; L_c is the distance between the inclines along the strike; a is the width of the barrier pillar; β is the angle between the room axis and horizontal plane; Q is the extraction face utilization ratio per day; t_1 is the time for relocation and installing the equipment in a new room; v is the ate of room face advancing; t_2 is the time for relocation and installing the equipment in a new block.

Interrelations between block length along the strike, extraction face utilization ratio, and width of rib pillar in case of mining and geological conditions of the Uong Bi mine (γ = 1.6 t/m^3, η = 0.8, m = 3.5 m, a = 4 m, t_1 = 3 days, t_2 = 7 days, β = 20°–25°; v = 10 m/day;) are illustrated in Fig. 3 and Fig. 4.

Based on analysis of the graphs in Fig. 3 and Fig. 4, we can draw the following conclusion: the distance between the chutes along the strike is directly proportional to the face utilization ratio and inversely proportional to the width of rib pillar. This conforms to the above-described results of testing room-and-pillar method under conditions of Uong Bi mine at the block length of 60 m. In each particular case the value of the optimum distance between the chutes is determined by expression (2).

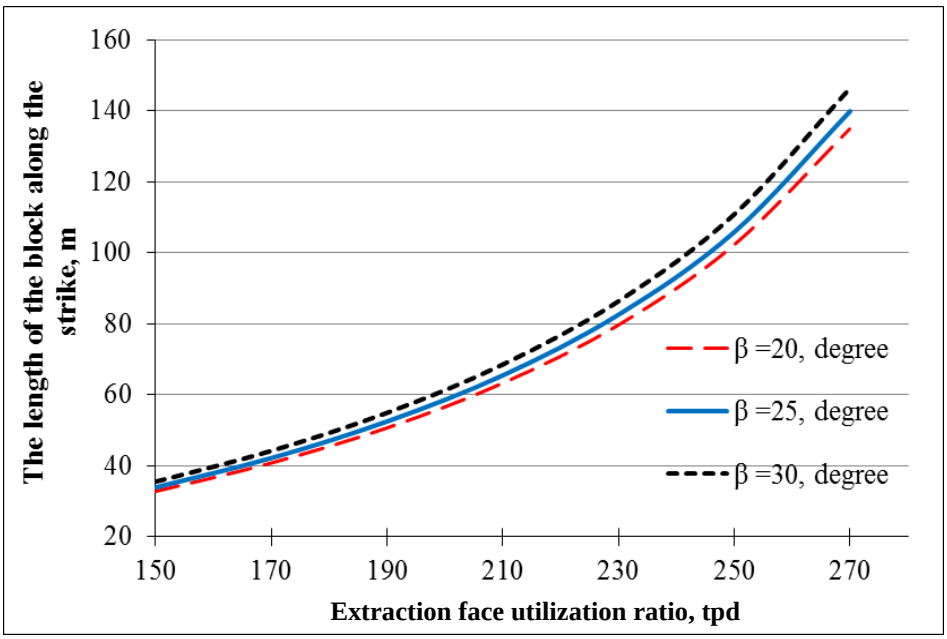

Fig. 3. Block length along the strike as a function of extraction face utilization ratio (at different β angles)

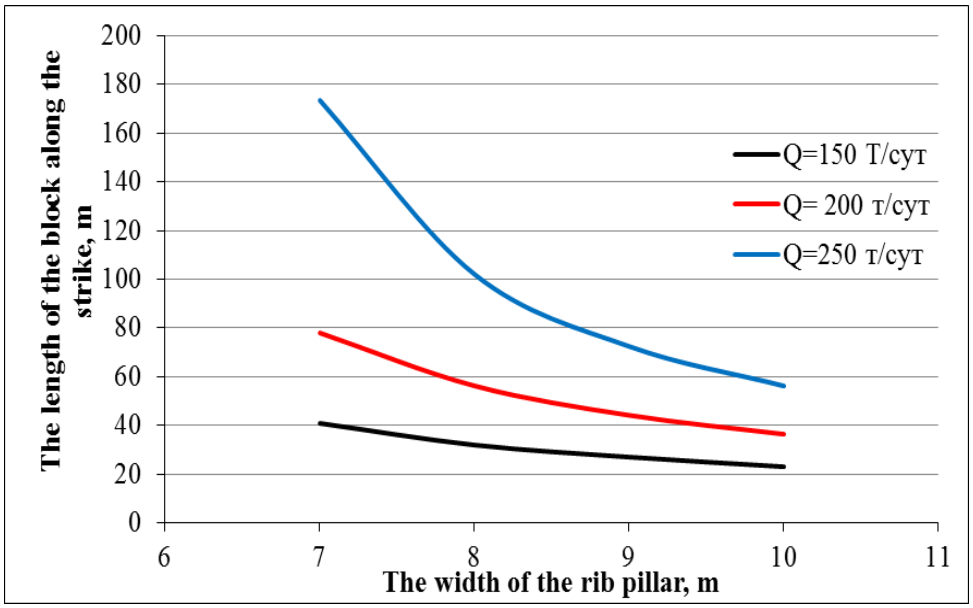

Fig. 4. Width of rib pillar as a function of block length along the strike at different extraction face utilization ratios (Q = 150, 200 and 250 tpd)

Conclusion

1. Based on advanced foreign experience with adapting to specific mining and geological conditions of the medium thick inclined coal seams in the Quang Ninh coal basin, options of flow sheets for applying room-and-pillar mining method for block extraction are recommended.

2. The optimal block length along the strike (distance between the chutes along the strike) to provide the production safety and efficiency was determined for extraction of medium-thick inclined coal seams by room-and-pillar method in the Quang Ninh coal basin. Interrelations between the block length along the strike, the extraction face utilization ratio, and the width of rib pillar for the case of mining and geological conditions of the Uong Bi mine were revealed and quantified.

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