MINERAL MINING TECHNOLOGY

COAL EXTRACTION FROM THICK FLAT AND STEEP BEDS

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The paper offers an underground geotechnology for thick coal beds based on the controllable force-feed extraction of pre-broken coal with using a re-designed powered roof support. Based on the discrete element method, the mathematical model has been developed for the numerical simulation of gravitation movement of granular materials. The two-dimensional problem about sublevel coal caving in thick beds is studied, and the effect exerted by the order of opening the roof support outlets on the coal extraction parameters is illustrated.

Power, roof support, underground coal extraction, gravitation movement, numerical model, discrete element method

INTRODUCTION

Extraction of thick coal increasingly involves powered roof supports to cut coal in layers adjacent to roofs, and in interlayers. Such technologies involve coal destruction with the help of the strata pressure. This fact allowed the powered supports to be functionally enriched with extraction control for coal above and behind the support. In Russian, Chinese, Kazakh, French and Czech mines, such supports have been used in coal cutting and extraction onto a front conveyor located in front of the support, closer to the working face, or onto a rare conveyor adjacent to the rare part of the back-end of the support [1 – 5].

Conventional labor-intensive slicing methods will certainly be replaced with the technologies including such supports as a basic element advantageous for: greatly cut down development work, investment and maintenance cost, energy intensity, coal combustion risk, as well as higher applicability to complex geology conditions and extractability of coal left in pillars. As a result, efficiency and safety of coal extraction grow while workload and concentration of mining increase.

With all the advantages, the technology has implementation difficulties primarily associated with coal extraction ratio, mechanization of coal haulage as well as safety and efficiency of a production face. Coal lost in a caved area may self-ignite. Besides, cut coal mixes with broken dirt roof rocks and final coal ash content increases. So, it is necessary to analyze the process of coal extraction through outlets in the powered roof support and to design a new coal cutting and extraction complex.

COAL EXTRACTION TECHNOLOGIES

There are two versions of the technology for cutting top coal in the roofs of mine workings: 1) coal feed to a front (face) conveyor with mining complexes KTU or KNKM (Russia), or VHP-731 (Hungary) illustrated in Fig. 1a and 2) coal feed onto a rear conveyor with mining complexes OKPV-70 and KM81V (Russia), or ZFC (China) shown in Fig. 1b.

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Technology version 1 features location of the support outlet close to the face. This allows for a small span of the support unit but provides no proper preparation of coal for cave-in as there is a short distance between the beam and the outlet. As a consequence, coal is to be pre-loosened, its extraction entails high dust generation and raises operational risk.

Technology version 2 (coal feed onto a rear conveyor) creates favorable conditions for deformation caving of the roof-adjacent coal layer. However, the support units should be long in this case, while the rare conveyor complicates the structure of the support and of the load-transfer device placed at the longwall juncture with a belt entry, which impedes its maintenance.

Common drawbacks of the both technological versions are that coal flow through the outlet is limited and, as a consequence, coal losses and ash content get higher, especially when coal fragments are coarse. With introducing coal extraction lengthwise the entire longwall, through outlets of all units of the support at the same time, the coal–rock contact will come down uniformly, which will allow for the extraction controllability throughout the longwall.

The throughout extraction makes it possible to cut coal in thick and complex structure strata, including strata in tectonically faulted rock masses, with variable thickness and dip angles, it also becomes possible to extract coal from previously left pillars, with largely reduced development works and no money needed for purchase of auxiliary high-price equipment, etc. In terms of the Kuznetsk Coal Basin, above 142 Mt coal reserves are extractable with the throughout technology.

Based on the research results achieved at the Institute of Mining, Siberian Branch, Russian Academy of Sciences [6–8], it has been offered to control coal flow in the course of its force-feed extraction by using a plunger feeder to deliver coal onto a front conveyor and a new design of the powered roof support (Fig. 2). The adjustable and proportioned coal flow above the roof support ensures higher coal production and lower dilution. In addition, the load of the front conveyor is under control, too, and no auxiliary conveyor is involved, which simplifies the geotechnology, especially at the longwall junctures with other workings.

The lipped feeder lies between hydraulic legs, under the roof top (outlet); its wedge-shape wavy surface ensures minimum resistance to movement towards the front conveyor and maximum friction and cohesion in movement towards the outlet. A hydraulic jack of the feeder is attached to the rigid platform (rod) and to lips (housing). There is an unloading platform to transfer coal from the feeder to the conveyor. The roof top and the base form the straight-line four bar linkage (Chebyshev linkage). The outlet screen is made as telescope jointed plates, has a hydraulic jack, and is hinge-supported in the roof top. The support unit can additionally include facilities to holdup a face breast, to ensure the unit stability, to support the front conveyor, to ensure effective backup when the support is advanced, to cover lateral clearances, and others.

Fig. 1. Coal extraction methods: a — upper feed to a front (face) conveyor; b — lower feed to a rare conveyor