SUBLEVEL CAVING SHIELDS AND THEIR UTILIZATION IN MINING OUT DISTURBED THICK COAL SEAMS

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ABSTRACT: *Introduction sublevel caving shields into coal mining was a great advance in mechanized extraction of thick coal seams. Utilization of these roof supports was advantageous not only in good geological conditions, but especially in broken coal seams full of faults, as a great loss of mineral reserve furthermore significant waste content is resulted by conventional slicing methods. A major advantage of shields of VHP-700 series could be considered that while other type of similar shields require two chain conveyors, only one conveyor should be built in the VHP-700 series equipment. Consequently conventional longwalling method could be used without significant changes. Application of the shields in question was safe, and resulted no higher coal loss and lower heating value than conventional longwalling methods. Structure of these roof supports and way of their utilization, including special elements of technology, such as provocation blasts and preparation of the raw coal, etc. are discussed in this paper.*

KEYWORDS: *sublevel caving shield, mechanized longwall, coal mining, provocation blasting*

1. UNDERGROUND EXTRACTION OF THICK COAL SEAMS

Modern mining methods are usually determined by the machinery, furthermore structure and performance of the equipment is adjusted to the mining method as a result of mechanization and automation of mining operations.

A special solution was introduced for mechanized extraction of thick coal seams or of several seams separated by rock layers. In the beginning mostly shortwall methods were used to mine out coal seams, which were broken as a result of geological forces.

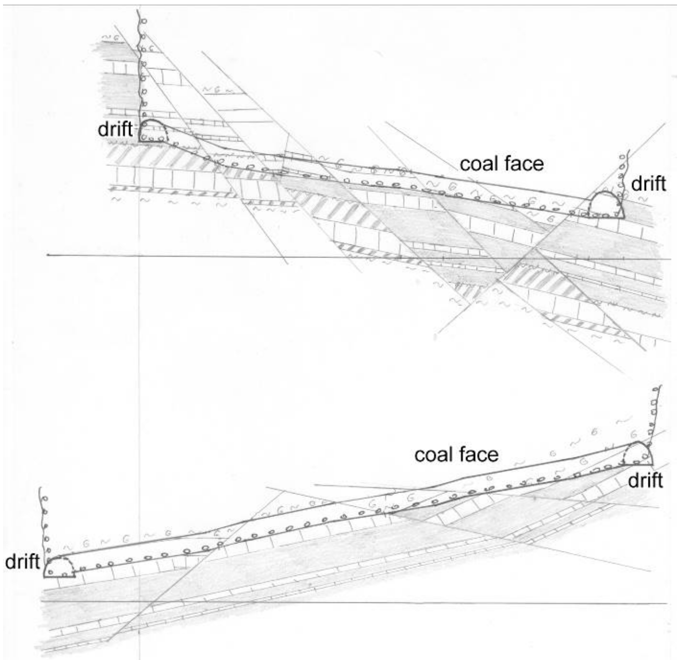


Fig. 1. Longitudinal sections of two longwalls, cutting mostly country rocks due to their momentary unfortunate position.

Then non-mechanized and mechanized longwalls were used to obtain higher output, slicing the seam parallel to its bottom surface [5-7].

Unfortunately slicing was usually impossible in broken seams, as sometimes the face of the longwall consisted of not coal but its country rocks resulting significant loss of extractable coal, furthermore deterioration of the heating value of the output of the mine.

Longitudinal sections of two longwalls of a Hungarian brown coal mine are shown by Figure 1.

Obviously a great part of the coal face is occupied not by coal but by its country rocks.

These sections were prepared by the mine as previous technical documentation.

2. STRUCTURE OF HUNGARIAN SUBLEVEL CAVING SHIELDS AND THEIR UTILIZATION IN THE EXTRACTION OF THICK COAL SEAMS

A great advance could be observed in the underground extraction of nearly horizontal thick coal seams and multilayer seams separated by rock layers in Hungary as a result of the introduction of sublevel caving shields.

These longwalls advanced along the bottom of the (lowest) coal seam, so coal and usually rocks too in the covering layers could be drawn and hauled by the chain conveyor along the face.

Several types of such shields were manufactured all over the world. In common these structures were equipped with two chain conveyors on the same longwall. One of them was on the face and the other on the rear side near the gob. Unfortunately any confusion (breakdown or jam) resulted serious problems in their operation.

More favorable experiences were obtained with the operation of the sublevel caving shields, designed and manufactured in Várpalota (Hungary). Several types of the VHP-700 series (Fig.2) were in operation in numerous underground mines.

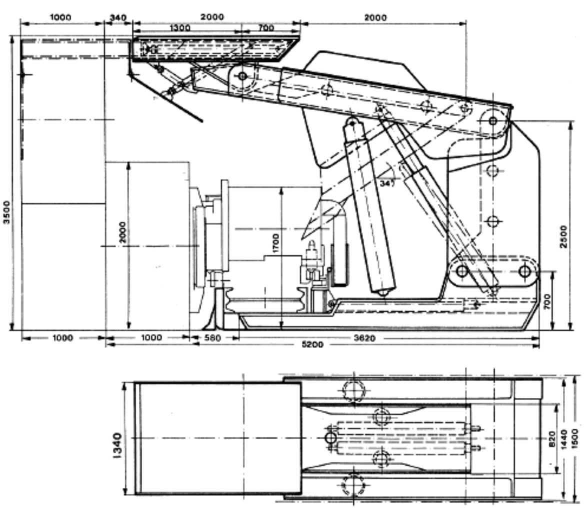


Fig. 2. The VHP750 sublevel caving shield

These shields are quite similar to the usual coal mining ones for the first sight.

The obvious difference is that a 2000 mm long door can be opened on the rear shield enabling drawing coal from the covering strata, and this door can act as a chute, moving the drawn coal on the chain conveyor on the coal face.

Consequently rear conveyor is not necessary, thus increasing reliability of the longwall equipment. The canopy equipped with built-in extendible cantilever and flipper sprag is 2000 mm long too.

The maximum height of the shield is 3500 mm, its width is 1500 mm. The 2000 mm long door enables drawing covering strata after each 1, 2 or 3 steps of advance at several (usually three) points of the coal face.

During drawing the shearer is out of operation and is staying at the tail end of the longwall enabling maximum cross section of coal stream in the conveyor pans.

Operating range of the VHP742/1 sublevel caving shield is 2,6-3,0 m (Fig. 3), optimal height of the coal face is 2.8 m. Width of the units is 1500 mm, maximum length of advance is 700 mm. Length and width of the chute door on the rear shield is 2000 mm and 820 mm.

The VHP742/1 shield is 4 leg 4000 kN, the maximal force of each rear legs is 1000 kN supporting the door [3,4].

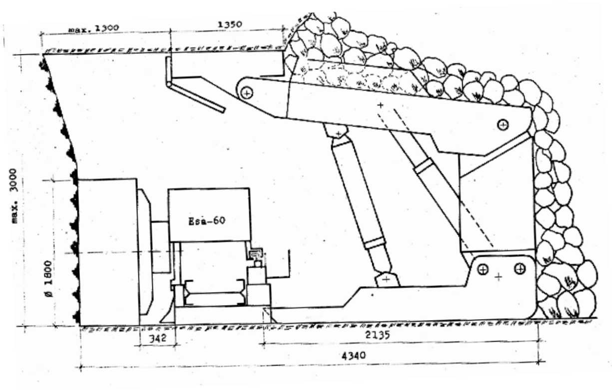


Fig. 3. Cross section of a longwall equipped with sublevel caving shields type VHP742/1 and ESA-60L shearer

3. UTILIZATION SUBLEVEL CAVING SHIELDS IN COAL MINING NEAR DOROG IN HUNGARY

Mechanized sublevel caving longwalling method was used as one of the mining methods in the Lencsehegy II. coal mine in Hungary.

The Lencsehegy coalfield was located on the northeastern edge of the Dorog coal basin. The 0-120 m thick bedrock was Dachstein limestone with cretaceous marl on it.

The 6-24 m thick group of seams contained totally 4-18 m rigid coal of a 21 MJ·kg^{-1} average heating value and three (2 m, 1.5 m and 0.5 m thick) limestone layers which made sublevel caving rather complicated.

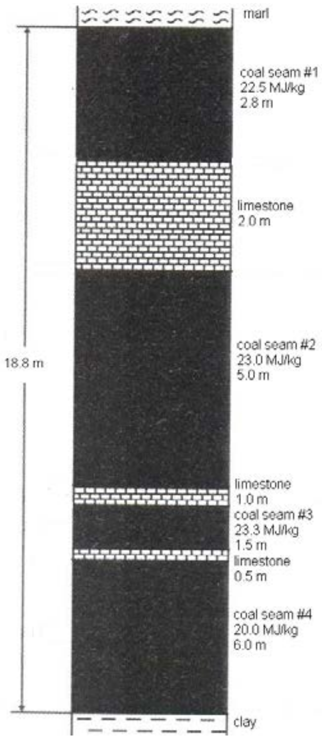


Fig. 4. Vertical section of the coal seams.

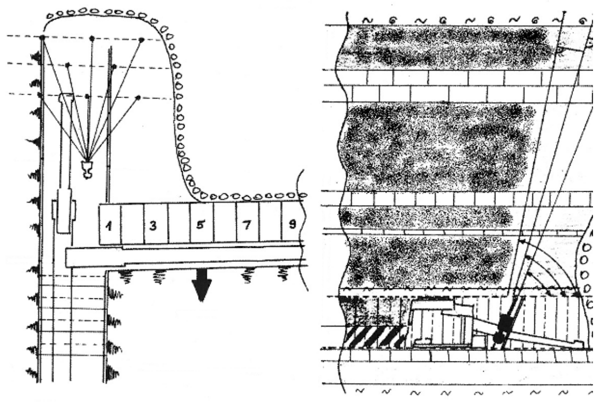
The horizontal area of the extractable reserve was 1.5 km^2. Method of extraction should have been selected very carefully, as a fatal accident occurred in another mine of the firm due to rockfall on a coal face. Vertical section of the coal seams and the limestone layers between them are shown on Figure 4.

Originally non-mechanized mining methods were used in the Dorog coal mines due to tectonic effects and sometimes remarkably higher inclination and variable thickness of the coal seams.

The first mechanized longwalls in the Lencsehegy coal mine were conventional ones, cutting the coal seams separately in three slices to avoid extraction of the limestone layers between the coal seams. Unfortunately the great number of faults made this method uneconomical. Some years of attempts made the following experiences obvious:

1. Cost of mining out blocks containing less than 70 000 tons of extractable coal is lower for non-mechanized methods, such as room-and-pillars and sometimes longwalls.
2. Mechanized sublevel caving longwalls proved to be more economical for blocks of greater reserves due to less fires, less drifting and maintenance. Furthermore loss of coal and degradation of the quality of the product was not higher than for conventional slicing method.

Sublevel caving regularly made provocation blasting necessary to enable continuous drawing of the covering layers. Location of the blastholes at the transportation drift is shown on Figure 5.



(5a) (5b)

Fig. 5. Crossing of the longwall and the transportation drift (5a) and the vertical section of coal seams and the blastholes along the drift (5b)

Blasting pattern is similar to the one used in quarrying [2]. A special set of blastholes for provokation blasting drilled from a room on the coal face was conceived by the coal mine itself as well. Obviously blocks of rock and coal are blasted too.

4. ECONOMICAL EFFECT OF UTILIZING SUBLEVEL CAVING EQUIPMENT

Remarkable increase of waste (limestone and marl) content, thus degradation of the average heating value of the product was one of the results of sublevel caving technology. But due to higher compressive strength of marl and limestone a very simple and cheap preparation method proved to be successful in making this technology economical.

The majority of marl and limestone content could be separated from the valuable part of the product using a 200 mm grid. The remaining part was crushed and classified using a two-plane sieve. As a result of this method fractions of bigger pieces of coal of higher heating value were obtained for domestic heating purposes, and coal dust of lower heat content for energetic purposes [1].

Economic results of the technology based on sublevel caving equipment are shown on Figure 6 .

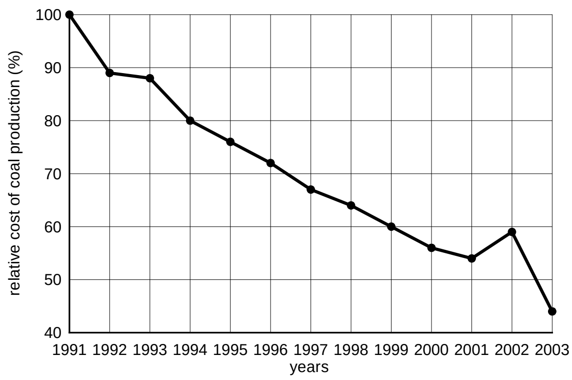


Fig. 6. Total cost of coal production corrected with the measure of inflation compared with the value of 1991

The production cost has been reduced by approximately 40-45 % from 1991 to 2003, thus providing value of the sublevel caving shields and technology in question .

5. CONCLUSIONS

Introduction of sublevel caving shields proved to be advantageous in the extraction of thick coal seams using mechanized longwalls, especially the series of VHP-700 series, which were designed and manufactured in Várpalota (Hungary). The main advantage of these equipment, that they fit very well to the usual longwall machinery and technology. Furthermore only one chain conveyors was required on the coal face instead of the two ones of other constructions of other manufacturers, resulting higher reliability. Two elements of the mining technology was worked out to increase efficiency. One of them was provocation blasting, enabling continuous drawing of the covering strata containing coal, marl and stiff limestone too. The other one was a simple but efficient preparation technology using crushing and classifying to produce lump coal of higher heating value for domestic heating purposes and energetic coal dust of lower heat content. All these innovations together resulted a 40-45 % reduction of cost from 1991 to 2003.

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