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BLASTING DEVELOPMENT AT DRIFTING IN UNDERGROUND COAL MINES

Radoje Pantovic*[#], Miodrag Zikic* and Zoran Stojkovic**

*University of Belgrade, Technical Faculty in Bor,
VJ 12, 19210 Bor, Serbia
**Megatrend University, Faculty of management,
Park Suma "Kraljevica" bb, 19000 Zajecar, Serbia

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Abstract

Blasting in drifting at underground coal mines has to meet numerous requirements in safety and techno – economic efficiency. Meeting these requirements is possible only in case of choosing optimal parameters for actual conditions of blasting. This paper shows basic principles for determination of blasting parameters in drifting. Limitations in technology and regulations cause difficulties in determination of explosive type, blasthole loading, layout and length of blastholes, initiation schemes.

After the analysis of currently applied blasting technology, this paper suggests changed blasting technology, based on theoretical and practical knowledge and experimental work in four Serbian underground coal mines: Senjski rudnik, Stavalj, Jelovac and Lubnica. Main parameters and gained results of new blasting technology for first two mines are presented. Blasting technology was changed through blastholes layout, load weights, initiation schemes, blasthole length and quality of blasthole sealing. Results have shown improvements in explosive consumption and efficiency of blasting. Besides, percentage of coarse fraction has increased, thus improving overall economic results.

Key words: *blasting, underground coal mines, drifting, methane explosives.*

1. Introduction

Serbian underground coal mines exist within JP PEU Resavica Coal Company. Drilling and blasting is the only technology applied in drifting. In coal extraction, 25 m of drifts are needed for gaining 1000 tons of coal, with 9 m of basic drifts.

Drilling and blasting play the key role in drifting efficiency. Blasting has to match following requirements:

- High safety requirements, especially in methane mines,
- Maximal use of blastholes, thus providing maximal face advance,
- Minimal deviation of actual profile in relation to designed profile,

[#] ***Corresponding author:*** *pan@tf.bor.ac.yu*

- High percentage of coarse fragments, until their transport limitations,
- Minimal dissipation of blasted coal and favourable shape of blasted coal cluster,
- Good drift stability with minimal demolition of roof and walls.

Necessary amount of explosive should be distributed in a coal seam in the manner which enables good blasting results with minimal explosive consumption and manpower.

In order to provide safety, efficiency and low costs, blasting technology should be constantly improved, thus enabling favourable economic results.

2. Basic principles in determination of blasting parameters

Satisfying blasting results in drifting may be accomplished only if blasting parameters are determined according to actual properties of working environment. Main blasting parameters are following: blasthole diameter, length and layout, type of explosive, diameter and weight of load, sealing, scheme of initiation [1]. These parameters depend on following: type and size of a drift, properties of coal or rock, properties of explosive, loading diameter, drilling equipment, etc.

Figures 1, 2 and 3 show empiric recommendations for specific explosive consumption, number of blastholes and their length in drifting in coal, depending on drift size and coal properties, given through Protodjakonov's strength coefficient (f) [2].

2.1. Specific explosive consumption

Specific explosive consumption is a base for determination of number of blastholes and some other parameters. Figure 1 shows recommendations for determination of specific consumption for 1,8 m long blasthole and 36 mm load diameter. In case of different input data, values of specific consumption should be corrected through corresponding coefficients.

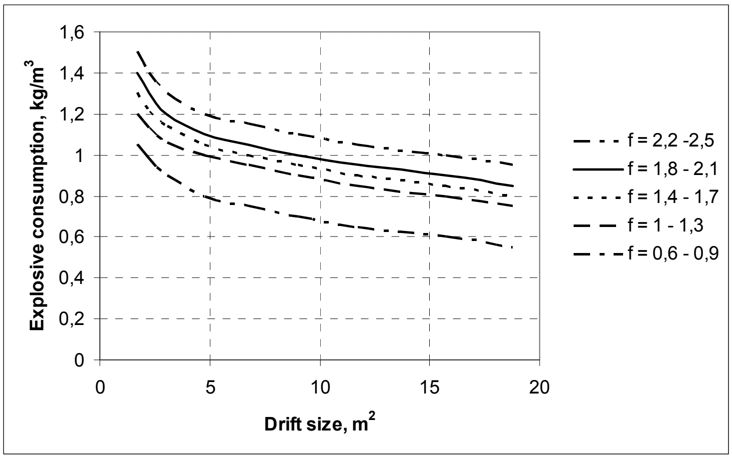

Fig. 1. Recommendations for specific consumption of explosive with 280 cm^3 blasting ability

2.2. Number of blastholes

Number of blastholes should be determined depending on designed blastholes' layout. It could be determined using empiric recommendations, by various authors. The diagram in Figure 2 is given for explosives with blasting ability between 280 and 360 cm^3, with 32 and 36 mm load diameter.

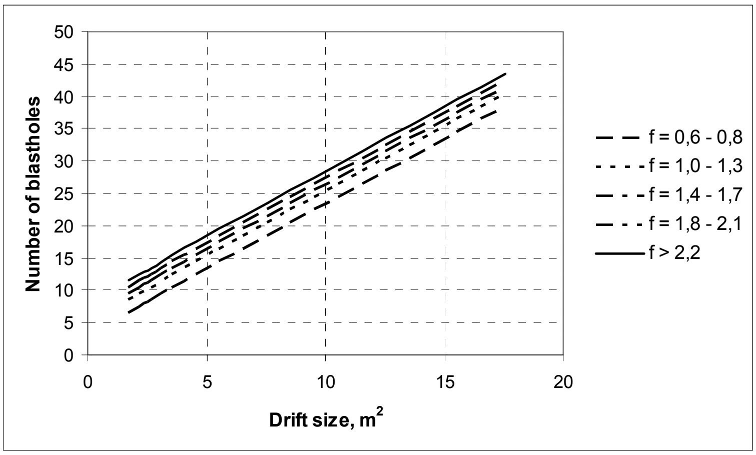

Fig. 2. Empiric recommendations for number of blastholes

2.3. Blasthole length

Blasthole length depends on drift size and coal properties (Figure 3). If the holes are too long, detonation is damped and blasting is unsuccessful. If they are too short, there is a danger that sealing would be short, too. In case of poor roof stability, blasthole length and face advance should decrease, to disable opening of large open surface, with danger of roof caving at the coal face.

2.4. Layout of blastholes

Layout of blastholes depends on explosive properties, coal or rock properties, size of drift, etc. Drifting in coal and soft rock requires inclined central blastholes, in scotch or pyramidal pattern. Pyramidal central blastholes are usually used in harder rock.

Central blastholes should be placed in drift center, or a bit lower. Such position, due to downwards oriented blasting, in direction of gravity, provides low dispersion of blasted material and low explosive consumption. If the drift passes through several strata with different properties, central holes should be placed in the hardest one. Empty central holes are not allowed in methane mines.

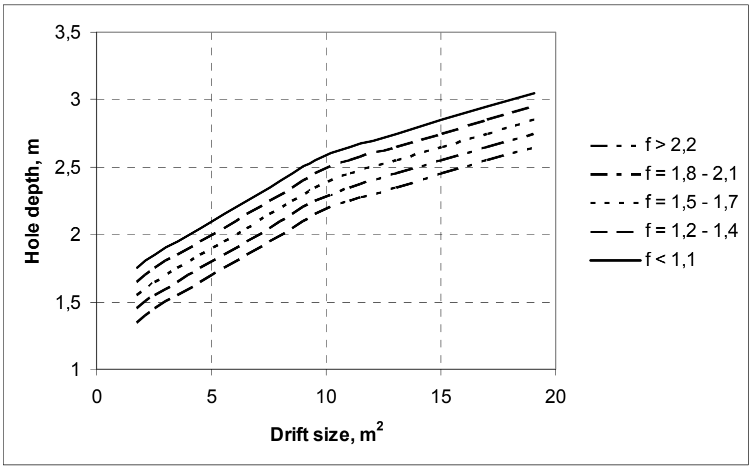

Fig. 3. Recommendations for blasthole length

3. Possibilities for corrections in blasting technology

Blasting in methane mines, or mines with flammable coal dust, must be performed according to regulations and standards. Serbian regulations in this field are very limiting in blasting parameters changing, such as type of explosive, initiation schemes, weight and diameter of loads, blastholes layout, etc. Even these regulations are very rigid and sometimes even irrational, they still have to be obeyed. Besides, limited offer of methane – safe explosives also diminishes possibilities for technology changes.

3.1. Type of explosive

Serbian coal mines practically have no choice in selection of methane – safe explosives. There are two available types – Metandetonit I and Metandetonit II. These explosives could be ranked between first and second class of security by German classification. These explosives must be handled with special level of security and must always be used properly [3].

3.2. Diameter of load

In the mines of JP PEU Resavica, difference between blasthole diameter (42 mm) and load diameter (28 mm) is 14 mm. Such a big gap weakens blasthole pressure of detonating gasses, especially when using weaker methane – safe explosives. Decrease of gap could provide better stability of detonation. By numerous authors [2, 4] optimal load diameter in methane mines is 32 to 36 mm.

3.3. Load weight

According to Serbian regulations, maximal load weight per hole is 0,6 kg (for 100 g loads), or 0,8 kg (for 200 g loads). However, in many countries with well developed coal mining, load weight is not limited. Instead, regulations refer to quality of methane – safe explosives. Such approach to this subject is more effective.

For instance, in the USA, maximal load weight per hole is not less than 1,36 kg. Low load weights may cause dangerous effects, such as deflagration or combustion of explosive and detonation suppression [5].

3.4. Blasthole spacing

Deflagration of explosive is often related to small blasthole spacing. By Serbian regulations, minimal spacing is 0,6 m in coal and 0,4 m in rock. Central blastholes, if they are inclined, mustn't interfere or cross each other, with minimal spacing at their ends of 0,4 m.

3.5. Initiation schemes and schedules

Danger of methane explosion increases with increase of overall initiation time. If initiation lasts longer, there are bigger chances for forming of artificial cracks, loads uncovering and their detonation in open space. Delay numbers of electric methane – safe detonators must follow one another, without skipping numbers and increasing delay time. Each country regulates overall detonation time in their mines. For instance, Russian regulations allow up to 135 ms overall delay in coal and 195 ms in surrounding rock. In Germany and USA maximal delay is 500 ms, in Poland 123 ms and in Serbia 136 ms, with delay between adjacent detonators numbers is 34 ms.

3.6. Blasthole sealing

Besides keeping of gas detonation products in the hole, the sealing has to stop flames and sparkles from entering into working area. Sealings with plastic ampoules or water jellies provide better safety and blasting efficiency.

4. Experimental verification of blasting technology corrections

After the analysis of current blasting technology, considering limitations in regulations and technology, some parameters were corrected aiming to improve blasting. Experimental blasting with corrected parameters was performed in four coal faces in following mines: Jelovac, Senjski rudnik, Lubnica and Stavalj [6]. Results of experimental blasting were following:

4.1. Experimental blasting in Senjski rudnik mine

After several trial blastings, correction of parameters was determined and applied in drift TVH 3-4, laid in coal seam. This drift was supported by iron arcs, with 3.5 m diameter. Before experimental blasting, explosive usage reached 0,85 kg/m^3, while electric detonators usage was 2,32 units/m^3. Auxiliary blasting was used very often.

After 24 experimental blastings, overall amount of used explosive was 338,2 kg and 716 electric detonators. Explosive usage decreased to 0,75 kg/m^3, while detonators usage went down to 1,59 units/m^3. Each blasting consisted of 29 blastholes, with 13,9 kg of Metandetonit explosive. Load weights per blasthole were 0,4, 0,5 and 0,6 kg, with higher weights in central blastholes. Blasthole length was 1,6 m. Average load ratio was 0,36. Nominal delay interval was 34 ms.

The sealings were made of clay (85 %) and sand (15 %). Figure 4 shows blastholes layout, detonator delay schedule and initiation scheme.

Overall face advance was 34 m, with only four auxiliary blastings.

Drift contours were good, blasted material disperse minimal. Drift contour repairs were also minimal, and roof stability was high.

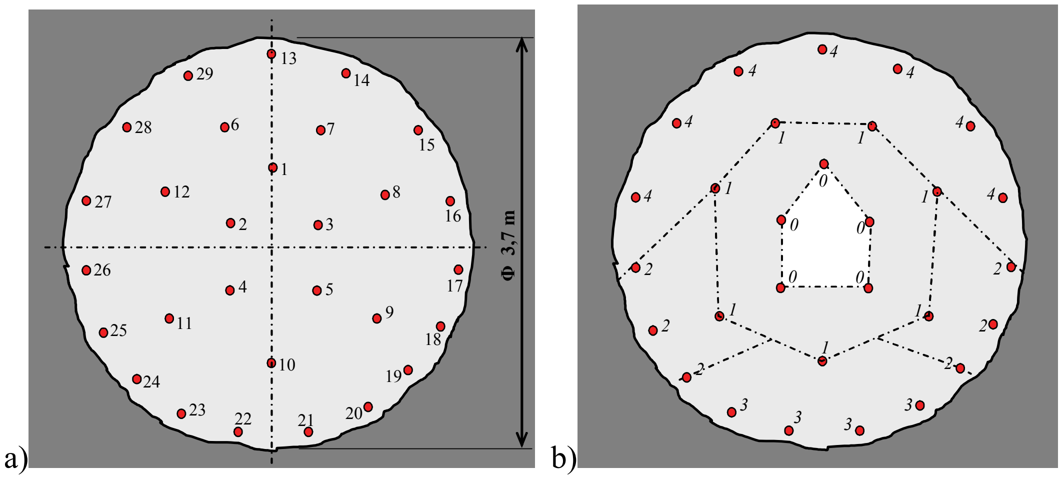

Fig. 4. Experimental blasting in Senjski rudnik mine; a) blastholes layout, b) initiation scheme

4.2. Experimental blasting at Stavalj mine

Experimental blasting with corrected parameters was performed in drift IOH – 860. The drift was supported by timber frames, in 0,8 m spacing. During the experiment, 8,5 kg of Amoneks explosive was used for each blasting. Load weights were 0,4 kg, 0,5 kg (in central blastholes) and 0,6 kg (in footwall blastholes). Blasthole length was 1,7 m and average loading ratio 0,32. Figure 5 shows blastholes layout, detonator delays and blasting scheme.

Before the experiment, explosive usage was 0,64 kg/m^3 and usage of half – second electric detonators was 1.57 units/m^3. After 15 experimental blastings, and overall face advance of 23 m, explosive usage was 0,43 kg/m^3 and detonator usage decreased to 0,91 units/m^3.

Very special result of this experiment was a fact that there was no auxiliary blasting at all. This enabled monthly face advance of 70 m, which is 50 % more than before the experiment. Average face advance per one blasting was 153 cm, which enabled placing of two timber frames after each blasting. Due to corrections in blasting technology, manpower usage decreased from 6,6 manshift/m to 4,7 manshift/m.

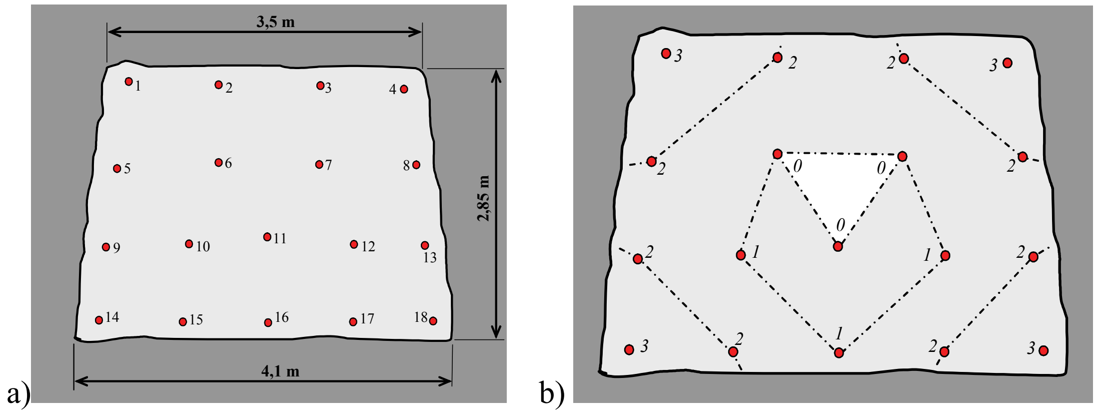

Fig. 5. Experimental blasting in Stavalj mine; a) blastholes layout, b) initiation and blasting scheme

Correction of blasting parameters brought the improvements of blasting effects in each mine. Usage of explosive and detonators significantly decreased, as well as manpower usage, thus enabling better production results. Besides, the percentage of coarse coal increased for 5 %. More coarse coal means better economic result for the mine.

5. Conclusion

After the analysis of experimental blasting, performed during several months in four mines of JP PEU Resavica Coal Company, results shown improvements in each segment of blasting technology. Experiments were performed in following mines: Senjski rudnik, Stavalj, Jelovac and Lubnica.

Correction of blasting parameters was determined based on analysis of current technology and use of theoretical and practical knowledge from countries with advanced mining. Possibilities for corrections of parameters were limited by regulations and technical and technological properties of mines.

Corrections were made in blastholes layout, central blastholes layout, load weights, initiation delays, blasthole length and type of sealing. These corrections provided increase of blasting efficiency through decrease of explosive and detonator usage, improved manpower productivity and increase of coarse coal percentage.

Blasting parameters should be corrected constantly, depending on current conditions. Technological discipline, blasting process control and analysis is necessary for constant improvement of blasting results.

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