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Professional paper

POSSIBILITIES FOR APPLICATION OF COAL MINING BY ROTARY DRILLING AT THE OPENCAST MINE GRAČANICA – GACKO

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Abstract: Application of coal mining in rotary drilling is possible in areas of the final slope, where a stripping ratio or infrastructure facilities on the ground does not allow further economical mining. Possibility for application of coal mining by rotary drilling conditions has been analyzed for opencast mine Gracanica - Gacko.

Key words: coal mining, rotary drilling

1. INTRODUCTION

Opencast coal mine Gračanica - Gacko is located in the southern part of the Republic Srpska and in the north-eastern part of Herzegovina. Annual coal production at the opencast mine is $2.2 \cdot 10^6$ tons, and is used to supply thermal power plant with capacity of 250 MW.

By opening and coal mining at the Field C of the opencast mine Gračanica, due to the inability of town displacement and relocation of communications, according to the design solution there are to remain significant reserves of coal convenient for the mining by rotary drilling (especially on the northern side of the final contours).

If it is to be shown by techno-economic justification, coal mining by rotary drilling has to be done before the final creation of the inside dump of the opencast mine Gračanica with the Field C.

2. COAL MINING TECHNOLOGY BY ROTARY DRILLING

Rotary drilling machines are used for excavation of horizontal and slightly inclined layers of coal (up to 20°) mainly with less thickness, without overburden removal.

These machines are adjusted to work on opencast coal mines during the excavation of coal layers in the non-working sides or from the special opening cuts (Figure 1).

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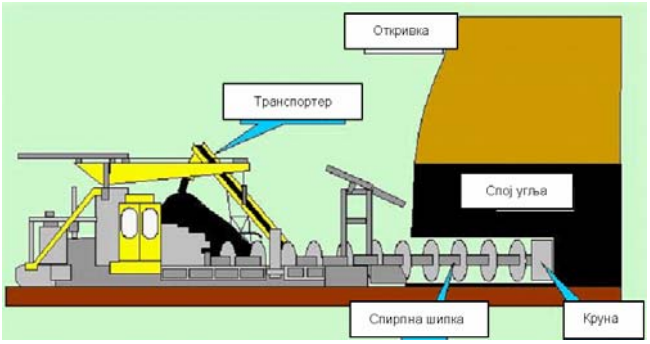

Figure 1 - Schematic review of coal mining by rotary drilling

Such exploitation is to provide pure and good quality coal, while significantly are to be reduced costs for separation.

Rotary drilling machines can be self-moving (crawlers or walking mechanism) or half-mobile (at rails) moved by dozers. Drilling and loading is to be made by diesel drive, while installation of equipment for drilling is to be done hydraulically.

Excavation of coal is to be made by large diameter drilling chisels, diameters of holes are in the range from 500 to 3000 mm. Borehole depth are even more than 200 m. Machines can achieve capacity up to 150 t/h. The material is transported to the spiral rods up to the transferring conveyor (Figure 2) and loaded onto the truck (Figure 3) or dumped to the bench (Figure 4).

Figure 2 – View of self-moving transporters

Figure 3 – Coal mining by rotary drilling and it load directly into truck

The first spiral rod for drilling set has a crown (Figure 5), and the other depending on the length is to be extended by sections. Crown diameter should be about 50 cm smaller than the thickness of coal seam. The last spiral rod is to be connected to the drilling set joint.

Figure 4 – Coal mining by rotary drilling and it dumped at the bench

Figure 5 – Spiral rod with a drilling crown

Drilling depth depends on the structural characteristics of rotary machines. Drilling speed is as average 1 to 1.5 m/min. However, the speed decreases with increasing depth.

3. COAL MINING TECHNOLOGY BY ROTARY DRILLING

Dimensions and allocation of boreholes are in the function of coal layers utilization, as well as stability factors and security of operations. To prevent overburden caving between boreholes in relation to the roof and bottom, are to be left safety distances. Width of the distance between the boreholes is determined depending on coal features, as well as roof and bottom materials, and from it depend coal losses.

Losses occur in the roof and bottom part of coal layer up to $0.2h$, where h is coal thickness. Therefore, it is possible drilling diameter up to $0.8h$. The distance between the boreholes can be determined by the formula:

$$b = d_b \Big/ \left(S_p \cdot K_k \cdot e \Big/ H \cdot G_o \cdot n_g \right)_{(m)} \tag{1}$$

Where:

d_b – borehole diameter (m);

S_p – resistance to single axis pressure (t/m^2);

K_k – coefficient of correction for borehole stability depending on the ratio of safety distance height up to the roof and borehole diameter ($K_k = \sqrt{h_s / d_b}$);

e – coefficient of rock material above the safety distance ($e = 1.1 \div 1.25$);

H – rock material height above the safety distance up to the ground (m);

G_o – average density of the roof material (t/m^3);

n_g – losses coefficient due to uneven pressure and changes to coal strength ($n_g = 2 \div 3$).

As a result of leaving the safety distances between boreholes and roof and bottom, coal losses during mining by rotary drilling are from 50 to 70%.

A simplified methodology for determination of safety factors for coal mining by rotary drilling is based on the comparison of calculated values of resistance to the pressure for the drilled coal layer and the load on the layer. Thus:

$$Safety\ Factor = Resistance \Big/ Load \tag{2}$$

Where:

$Resistance = 7200 \cdot W^{0.46} / h^{0.66}$;

$Load = 25 \cdot H \cdot A1 / A2$;

W – effective width of the safety pillar (m);
h – height of mining coal layer (m);
H – depth of coal layer from the surface (m);
$A1$ – total space of boreholes group at a depth of 1 m;
$A2$ – safety area surface between the borehole groups at a depth of 1 m.

The cycle of drilling a borehole (T_c) consists of drilling time (t_b), time for taking out a tools (t_v), time for screwing and adding, i.e., removing of one bar section (t_o+t_d), time for machine moving (t_p), directing time (t_u) and time for auxiliary, preparation and final operations (t_z):

$$T_c = (t_b + t_v) + (t_o + t_d) + t_u + t_p + t_z \ _{(\min)} \tag{3}$$

Total time for the drilling of the 70 m depth in coal, with an average drilling rate of 1.2 m/min (with the section length of 5.4 m and borehole diameter of 1.8 m) *i*s about 95 minutes. Time for removing the operating tool at the average removing speed by the section of 2.5 m/min, is approx. 65 minutes.

Technical machinery capacity for coal mining by rotary drilling can be obtained from the following formula:

$$Q_t = 60 \cdot Q_u / T_c \ _{(t/h)} \tag{4}$$

Mining shift capacity is:

$$\begin{aligned} Q_e &= 60 \cdot Q_u \cdot T_s \cdot K_s / T_c = \ldots = \\ &= 60 \cdot S_b \cdot L_b \cdot G_u \cdot T_s \cdot K_s / \left((L_b / v_v) + (L_b / v_v) + 2(n-1)(t_o + t_d) + t_p + t_u + t_z \right) _{(t/sm)} \end{aligned} \tag{5}$$

Where:

Q_u – coal quantity from one borehole (t);
T_c – cycle time (at the given conditions is the amount of operations time for the realization of one borehole (min);
S_b – the borehole cross-section (m^2);
L_b – the borehole length (m);
G_u – coal density (t/m^3);
v_b, v_v – average drilling and extraction speed (m/min);
n - the number of bars sections for the entire borehole;
T_s – the number of working hours per shift;
K_s – coefficient of shift-time utilization;
t_o, t_d – time for screwing and adding, i.e., removing of one bar section (is approximately $t_o = 1$ min, and $t_d = 2$ min).

The largest impact on the machine capacity has a borehole diameter and number of simultaneous drilling. Machine capacity during simultaneous development of two or three boreholes is two to three times higher than in a single borehole.

Coal mining by rotary drilling allows large output effects per worker, considering the shortening of time for the organization of coal extraction, rapid achievement of designed capacities, a minor increase of cost for capacity and level of production processes mechanization increasing.

4. POSSIBILITY FOR THE APPLICATION AT THE OPENCAST MINE GRAČANICA

Beyond the final contours of the opencast mine Gračanica-Gacko at the part of coal deposit Gacko, are to remain significant amounts of coal not mined. Possibility for application of coal mining by rotary drilling has been analyzed at layers outside the final northern contours in the length of 1500 m at an angle of 8°. Typical cross-section of this curve is shown in Figure 6, while borehole B-525 details are set out at Figure 7.

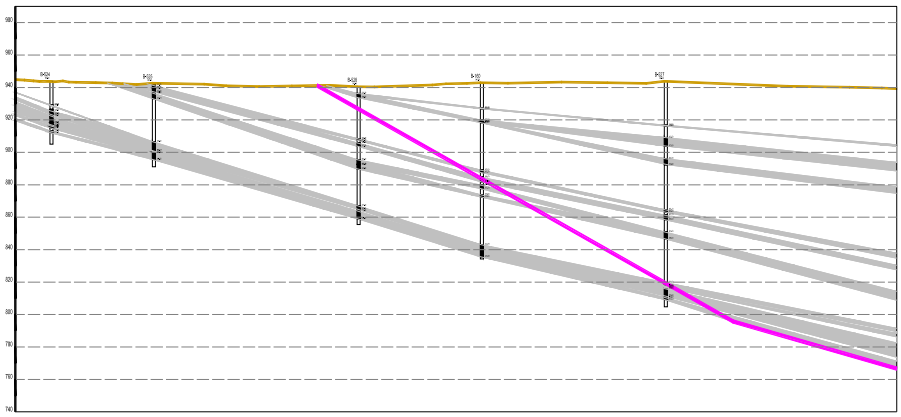

Figure 6 - A cross section of final northern contour

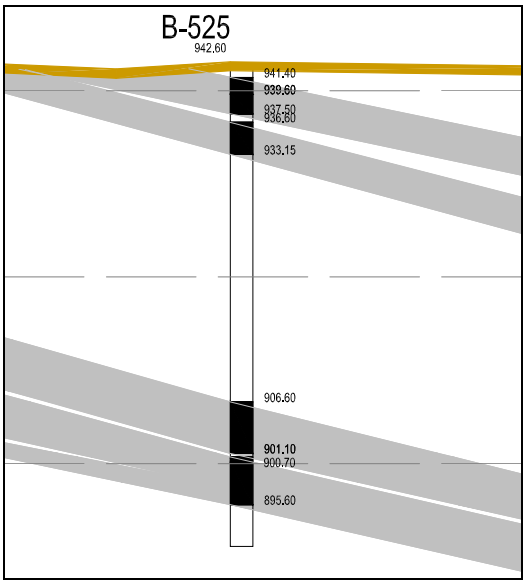

Figure 7 - Details of borehole B-525 in the final northern contour

By the iterative analysis have been selected parameters for the calculation of the distance between the rotary boreholes on the coal mining, for the height of the safety area up to the roof of the bottom coal layer of 0.5 m. Thus, the distance between boreholes is as follows:

$$b = d_b / \left(S_p \cdot K_k \cdot e / H \cdot G_o \cdot n_g \right) = 1.8 \left(900 \cdot 0.5 \cdot 1.2 / 35 \cdot 2 \cdot 2 \right) = 0.5m$$

The geometry of the accepted boreholes distance in two rows is shown at Figure 8.

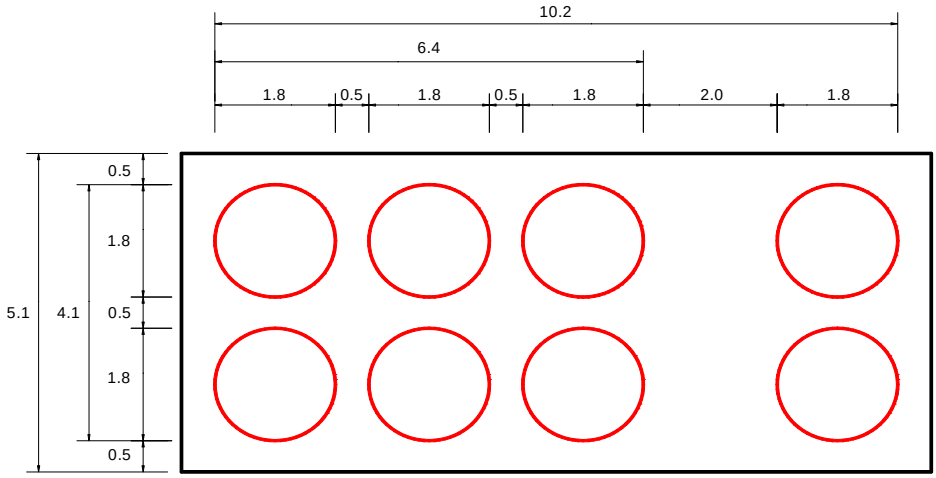

Figure 8 - The geometry of the accepted boreholes distance

Safety factor for the coal mining by the two-row basis boreholes based on the accepted parameters has been obtained as a ratio of the calculated resistance values to the drilled coal layer pressure and load at the coal layer.

Since:

$$Resistance = 7200 \cdot W^{0.46} / h^{0.66} = 7200 \cdot \left(2 \cdot 2 \right)^{0.46} / 4.1^{0.66} = 5368kPa$$

$$Load = 25 \cdot H \cdot Al / A2 = 25 \cdot 35 \cdot \left(1.8 + 0.5 + 1.8 + 0.5 + 1.8 + 2 \right) \cdot 1 / 2 \cdot 1 = 3675kPa$$

Safety factor is:

$$Safety\ Factor = Resistance / Load = 5368 / 3675 = 1.5$$

Utilization of coal layer thickness of 5.1 m by rotary drilling mining is 35.6%.

Mining shift capacity per drilling depth of 73 m with 13 segments, with an average drilling speed of 1.2 m/min and average speed for equipment taking out of 2.5 m/min, with coal volume mass of 1.27 and coefficient of shift-time utilization of 0.7 is:

$$Q_e = 60 \cdot S_b \cdot L_b \cdot G_u \cdot T_s \cdot K_s / T_c = 60 \cdot 226 \cdot 5.6 / 180 = 422 t / sm$$

For the semi-automatic shift operation of this mining system, with transport of coal by trucks, it required 6 employees, which allows relatively high utilization of

labour force with approx. 16000 tons per year per employee, for two-shift operations with the annual time of operations 3000 hours.

5. CONCLUSION

Coal mining by rotary drilling machines of different manufacturers is present worldwide for many years. This system of coal mining is characterized by safety operations and effective results of production.

At the opencast coal mine Gračanica-Gacko in the closing stage, and the future opencast mine Field C, there are all the technical and technological conditions for long-term use of coal mining by rotary drilling in areas outside of the final contours.

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