

**THE IMPLEMENTATION OF MODIFIED PILLAR METHOD
IN THE EXCAVATION FIELD 2 (OP-2)
IN THE "OSOJNO-JUG" RL "LUBNICA" MINE**

**PRIMENA MODIFIKOVANE STUBNE METODE U OTKOPNOM
POLJU 2 (OP-2) U JAMI „OSOJNO-JUG“ RL „LUBNICA“**

Dubočanin Milan¹

Received: November 16, 2015

Accepted: December 4, 2015

Abstract: According to the present geologic conditions, designing the modified pillar method of excavation with felling roof coal and collapsing the roof is mandatory and that is one of the goals of this method.

Considering the planned growth in production in OP-2, the need for the modification of present coal exploitation in the deposit of the "Lubnica" pit is imposed.

The fact that the present method of coal excavation marks more than 40% loss of balance reserves, which is unacceptable amount of excavation loss, is the main reason for changing the excavation method.

Key words: coal, excavation method, underground mine "Osojno-jug", Lubnica

Apstrakt: Prema sadašnjim geološkim uslovima neophodno je projektovati modifikovanu stubnu metodu otkopavanja sa obaranjem krovnog uglja i zarušavanjem krovine što je jedan od ciljeva ove metode.

S obzirom na planirano povećanje proizvodnje u OP-2, nameće se potreba za modifikacijom dosadašnje eksploatacije uglja u ležištu jame rudnika „Lubnica“.

Osnovni razlog za izmenu metode otkopavanja je činjenica da se kod postojeće metode otkopavanja uglja gubici bilansnih rezervi kreću i preko 40%, što je nedopustivo visoka vrednost otkopnih gubitaka.

Ključne reči: ugalj, metoda otkopavanja, jama „Osojno-jug“, Lubnica

1. INTRODUCTION

The complex geological structures and block structure of deposits didn't make the implementation of modern excavation methods possible (a broad forehead method, for example). This modern method assumes mechanization in working operations in the technological process of coal formation. That is why the pillar excavation method has its use in the deposit of coal mine "Lubnica". This method consists of basic phases

¹ JP PEU "Resavica", RL "Lubnica", Lubnica bb, 19208 Lubnica, Serbia, e-mail: milan.dubocanin@jppeu.rs

like: the excavation preparations in the form of inclined layers in retreat excavation and mining activities.

Based on recent geological and mining research, the coal deposit of "Lubnica" mine is characterized as a region with highly complex geological structure. The deposit is large in width and length, but the considered tectonics caused disturbance in the regularity of layer and accompanying rocks, by providing and fall, so the deposit of "Lubnica" is classified in the group of deposits characterized by block structure and planting zones interrupting the continuity.

Having in mind that this type of work is possible in the conditions of 5 m to 6 m thickness of a coal seam, the problem with the rest of a coal appears.

The mine "Lubnica" has the coal seams thickness over 6 meter, and it can reach 10 meter, so in this complex conditions the existing method should be modified and the proper way of safe work above ground to get significant amounts of coal should be found.

2. EXCAVATION IN THE EXCAVATION FIELD OP-2

The "T", "G" and "V" "Pillar methods of excavation" were applied so far for the excavation in the "Old pit" and in this part of the deposit "Osojno-jug". The "Lubnica" mine use those methods for years and the results have been satisfying in the limits of the pylon excavation method.

The basic phases regarding the most used pylon "T", "G" and "V" methods consist of:

- Preparation of railway-sloping pillars (basic preparation);
- Excavation prepare;
- Excavation;
- Collaps of excavation.

The excavation in this excavation field of the deposit "Osojno-jug" on the west from line R-10, started from basic levels OTH-1 and OTH-2. Lightweight gravel transporter with two transport chains the coal in this area and in excavation work sites to the room TH-2B where the conveyor belt is located. At the excavation base, in every moment there will be three active work sites (two in retreat and one progressing) and one work area for constructing the next basic level (e.g. OTH-3, etc.) (Technical documentation of the "Lubnica" mine).

3. MODIFIED PILLAR METHOD

The modified pillar method by providing a layer with the excavation of entire potential of layer in the conditions of "Lubnica" mine consists in the excavation of layer of approximately 7 m potential, with leaving the protection panel and the rehabilitation of the excavated area with roof caving. The inclination of coal seam that would be excavated by this method should be from 10° to 25°.

3.1. Technology of making basic and excavation preparation

This room is going to be made by drilling and mining technology. The mine holes drilling will be done with pillar drills, and the methane explosive and millisecond electric detonator will be used for mining, considering that the pit is categorized as the methane pit. Gravel transporter will transport coal from work site applying manual loading.

3.2. Support of worksite background and excavation prearrangement

Areas for basic and excavation preparation are made in loose iron arc timber protection. Dimensions of cross-section are 400 cm x 302 cm, or light areas of cross-section $S_s = 9.16 \text{ m}^2$.

The support on 1.0 m axial distance is done after every completed mining cycle.

Areas support is done with an arc timber protection.

For the protection from the large pieces crumbling the sides and roof of the area are supported with wooden truss with dimensions of 5 cm x 10 cm x 120 cm. The frame of the timber protection has to be set upwards on the floor and longitudinal axes of the area. It has to be well spanned and tight. Setting the segments into the frame is being done with connectors. When the arc timber protection is loose, and the frame has three parts, the joint connection of elements is made in two spots with two connectors on the binding place (Kobliška, 1966).

3.3. The selection of geometry of the excavation unit

Constructing the area of basic preparation in our case OTH's, approximately by spreading of the coal seam in its underlying stratum part, in the distance of about 35 m, spread excavating pillar 35 m x L (L is the length of excavation field by spreading of the coal seam) is being formed.

Spread excavation pillar formed in that way with dimensions of 35 m x L by excavation raise OU, divides on smaller excavation pillars with dimensions of 9.5 m x 35.0 m which represent excavation unit. Excavation in such formed excavation unit shall be at the coal seam with tilted upright digs (Glušćević, 1974).

Geometry of an excavation unit is associated to the potential of seam (layer) and physical characteristics and mechanical properties of work area and accompanying rocks (roof and floor). The basic dimensions of the projected pillar method's excavation unit are:

- Unit length of excavation: 35.0 m
- Unit width of excavation: 9.5 m
- Unit height of excavation: 5.0 m to 7.5 m
- Width of the lateral wing compared to the old work: 3.0 m
- Width of the lateral wing compared to the next pillar: 2.2 m
- The distance between raise excavations: 9.5 m

- The distance between two excavations one next to another in the same excavation pillar (the angle of the excavation field's progress must not be less than 45°): 9.5 m
- Thickness of the protection panel: 1.0 m
- The angle of slope with manually loaded material: 35°
- Step of fan of a deep mine boring: 1.2 m to 1.5 m

The geometry of excavation units and excavation dispositions in one excavation pillar is presented with figure 1.

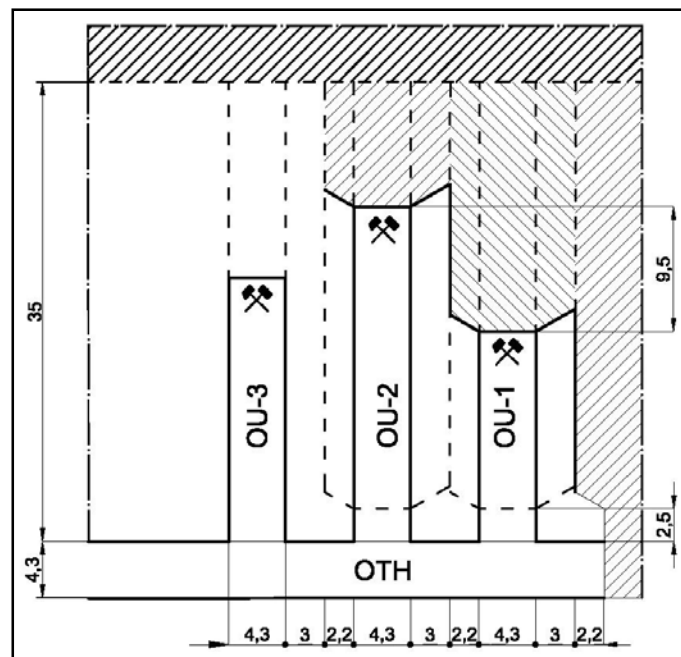


Figure 1 - The disposition of excavation in one excavation pillar

3.4. Technological process of excavation activities

3.4.1. System of activities on the excavation unit

Based on given solutions regarding geometry and elements of the chosen modified excavation method with bringing down roof coal by deep blast holes (in the fans) and the roof caving, the next technological solutions for the work on the excavation unit and for the excavation of spread pillars are foreseen:

- Phase I – constructing excavation raise;
- Phase II – getting coal from lateral wings in the underground and above ground areas and above the excavation raise in the area above ground;
- Phase III – getting coal above the intersection of transport or ventilation corridor and excavation raise;
- Phase IV – demolishing of excavation.

I EXCAVATION PHASE

Building of excavation raises is in rising coal seam in the foot wall part (up to shelf). Length of the excavation raise is cca 35 m of cross-section outbreak 400 cm x 302 cm. The support of excavation raise is made with iron arc timbering or with wooden trapezoid frames (400 cm x 280 cm x 295 cm), the thickness of mining material Ø20 cm to Ø 25 cm. If wooden trapezoid frames are being installed, than they are strengthened with 4.0 m long underscore leaned on two pillars. If necessary, wooden frames can be strengthened by middle pillars.

Excavation raises are made from excavation transport corridors, by rising coal seam at the inter-axial distance of 9.5 m.

The next phases of work are done in this excavation phase:

- Drilling of mine borings;
- Mining;
- Ventilation;
- Installation of ridge;
- Coal transportation;
- Supporting, installation of frames (pillars) and devotion of sides and roof;
- Auxiliary works (installation of underscore, extension transporters, ventilation pipes, etc.).

When excavation allows miners to rich 0.5 m distance from old work, the work on I phase of excavation is suspend and the preparations for the II phase of excavation start.

II EXCAVATION PHASE

When excavation raise (OU) came to 0.5 m from the old work of previous spread excavation pillar begins felling of coal roof and taking the side pillars. The second phase of excavation consists in opening (widening) of the excavation by mining in fans forming of the excavation space (OP-0) and successive forming of the next excavation spaces (OP-1), (OP-2), (OP-3), (OP-4), (OP-5) and (OP-6) in sections of 4.8 m by blasting in fans. Opening of the excavation, or forming excavation space (OP-0) starts with making the first fan of deep mining borings (OL-01). After the executed mining, ventilation, and coal transportation from work area, the second fan of mining borings is being drilled (OL-02). When mining, ventilation and coal transportation is done, the third fan of mining borings (OL-03) is being made, and then, after mining, ventilation, coal transportation and shortening of gravel conveyer the fourth fan is being made (OL-04). When drilling, mining, ventilation and coal transportation is done, follows the expected remediation excavation area 3.7 m long and cca 9.5 m wide excavation space (OP-0), by caving the roof strata above the excavation area. After the works in the opening of the excavation space (OP-0), the works on the further exploitation begin. They are done in the excavation area OP-1. Those works are done with 4 mining cycles with normal mining fan (OL-1.1, OL-1.2, OL-1.3 and OL-1.4).

After mining, ventilation, coal transportation etc. follows the expected remediation excavation area (OP-1) by caving the roof strata above the excavation area. The excavation of coal and excavation repair is done the same way in the rest of

excavation areas (OP-2, OP-3, OP-4, OP-5 and OP-6) till the 2.5 m from the basic transport corridor (OTH) or (VV), when the work on the excavation in the II phase is done and when the preparation for excavation in III phase is starting.

In the second phase of excavation, at the appropriate places in the spoil, it is necessary to set up a protective barrier, before blasting of the mine boreholes avoid large "spillover" of mined coal and uncontrolled penetration of the old working in exhumed workspace.

III EXCAVATION PHASE

Obtaining the coal from the crossroad of collective, respectively ventilating reise is done in sections, by constructing mine fans OL-1, OL-2, OL-3, OL-4, OL-5, OL-6, OL-7 and OL-8. Works on ventilation, transport of coal, additional works, etc., are being performed in every stated mining cycle.

Pillar of coal around the excavation and crossroads has a different geometry of the excavation area in relation to the pillar of coal excavation around the hall, and for this reason are designed for digging-range mine for excavation of the excavation. It is predicted that the excavated pillar in III phase be dig with 8 digging fans in duration of 8 working cycles.

Before subversion of the surface coal in front of every mined section, the so-called safety door is being installed which consists of cross underscore based on 4 scissors-like pillars. Vertical barrier is put to the door in order for coal or older works not to get through in the working space.

As well as in II excavation phase, in order to obtain coal in the appropriate places in this phase it is necessary to set the safety door with the secure barrier, with the same purpose as in the II excavation phase.

IV EXCAVATION COLLAPSING PHASE

The roof is collapsing just before taking one normal section, i.e. when there are enough wideness and longitude that the roof can collapse by itself. The side old work from the previous excavation also comes with the roof in the new space after taking the side pillow.

As to the physical-mechanical characteristics of the roof layers of marl, there is no danger from creating big collapsed space, since these rocks are suitable for collapse.

If, after taking coal on the length of 4.8 m, the collapse of the roof does not occur, it is necessary to make force collapse by using long mine drills which are made into the roof of the excavation from the supported section, which should be defined during the performance of probation work and using the instructions from the Pit Manager.

After establishing the collapse line in excavation pillar - excavated columns, it is necessary to dynamically manage excavations so that this line does not substantially disturb, which will allow timely roof caving, and therefore much safer work at the face (Genčić, 1972).

3.4.2. Drilling and blasting operations at the excavation

CHOICE OF EXCAVATION TECHNIQUES

For works on the excavation of coal mining method for providing a layer provides the appropriate techniques and equipment, as follows:

- Hand-held rotary electric drills;
- Associated converters;
- Cave pole drill JSB-20;
- Earth augers with extensions length of 1.0 m; 1.5 m and 3.0 m, a diameter of 38 mm diameter;
- Drill bit diameter 42 mm;
- Miners sticks with joints;
- Semi-automatic pneumatic filling of explosives;
- Power Hand Jack;
- Other instruments, accessories and tools for working on excavation unit.

Do not rule out the use of other techniques for excavation, if the mine already possesses it.

EXPLOSIVES AND MEANS FOR INITIATION OF EXPLOSIVE CHARGES

Pit Mine "Lubnica" is categorized as a methane pit. The pit is used for blasting explosives methane-detonit and for initiating explosives used millisecond electrical detonators.

For the purposes of mining by this method of excavating, the explosives and the means to initiate are adopted, which are already in use in the pit of the mine "Lubnica".

Initiating explosives designed for the overhead modified method will be done by using millisecond electric detonators 34 MSED-Cu conductive 2x2 (2-7) m, (SRPS H.D3.110).

a) Mining in the first excavation phase

The first stage of excavation - making excavations, will be carried out through un-mechanized technology for blasting operation.

b) Mining in the II and III excavation phase

Mining in the second phase of excavation applies the system of (12) twelve of mine holes arranged in a fan, while the mining operation in the third stage of excavation applies system of (7) seven mine hole arranged in a fan. The depth of drilling depends on the thickness of coal seam in excavation and side pillars, as well as the position of mine holes in the range.

When the thickness of coal seam is about 7 m and height of excavation in the I phase is 3.1 m, the length of boreholes in the range (phase II), in over digging place will be from 2.9 m to 4.4 m, taking into account the angle of 70° towards the ceiling level at which are boreholes drilled in over digging place.

With a given length of boreholes from 2.9 m to 4.4 m, mine construction and technical parameters of blasting at the excavation place, coal layers of thickness up to 7 m can be dug. In the projected mine fans, mine wells for coal seam of thickness of 7 m are carried out, and they are the most difficult to produce and are the most critical

for all budgets. For coal seam of thickness of less than 7 m all elements of the projected mine fan retain, construction of boreholes retain, technical parameters of blasting at the excavation place retain, as well as the position of boreholes in the range and the working system on excavation unit. Only the length of the boreholes in the mine range must be adjusted to the specific thickness of the coal seam in the over excavation place, which regularly needs to be controlled at the excavation area. About changes and adjustment of the length of boreholes in the excavation mine range with a specific thickness of coal seam decide a person responsible for this work in the mine.

As already pointed out, for each mine borehole is planned split charging (upper and lower) with explosives and milli-second electric detonators to initiate the explosion. With both explosive charges can be used wood, water or clay corks for clogging of boreholes or just clay corks.

Charging of the boreholes can be pneumatic and manually. In the case of manual charging specific devices may be used. One of them is when on the "laštuk" (stick for mine boreholes charging), we put a piece of clay and then successively put explosives into the borehole, wherein the clay is used to keep the explosive in the hole after charging. Also, charging of boreholes can be done with the "O kiten" hose, on which is placed wooden inlay and clay. These modes of charging are also applying in the mining practice. Coal seam of thickness below 7.0 m can be excavated with the projected blasting system in fans, with that mine borehole of length below 1.6 m is charging with one-piece explosive charge (which is again depending on the length of the explosive cartridge).

CALCULATION OF BLASTING PARAMETERS FOR THE II AND III PHASE OF EXCAVATION

In the fan-shaped arrangement of boreholes, the line of the least resistance (W) is calculated by using the formula:

$$W = 33 \cdot d_b \cdot \sqrt{\frac{\mu}{q \cdot k_z}} \quad [\text{m}] \quad (1)$$

where:

d_b - diameter of the boreholes, (0.042 m);

μ - charging coefficient which depends on the diameter of the borehole (0.64);

q - specific consumption of explosives, (0.296 kg/m³);

k_z - the coefficient of the bringing together of mines from which the granulation of mined material depends (ranging from 0.2 to 1.4), adopts 1.0.

The number and the length of the boreholes were determined by graphical method.

As the power source for mines detonating mines, the machine for detonating mines type EKA 400M™ will be used. The projected schedules, construction of the mine in the range are given in figures drawings.

During the excavation in test mode, will be checked again and generalized the construction of boreholes, geometry of mining range and technical parameters of blasting at the excavation place.

3.4.3. Loading and transportation of coal from the excavation

In parallel with the preparation of excavation of excavation upper digging place, in it, for the transportation of coal, is installed the double-stranded gravel transporter type TS-74.

Loading of coal is carried out manually into gravel transporter. Transporter is placed directly to the forehead of worksite, so a larger quantity of mined coal could immediately fall on the transporter. The rest of the coal is loaded manually with hoes and shovels.

When bringing down the roof coal, loading is carried out from the place which is supported by beams on the transporter with hoes and other hand tools with the handle of about 3 m.

From the transporter from excavation place, coal is falling down on transporter which is placed in excavation upper digging place even during its preparation. With it, coal is transporting to the common transporter, and then, by the gravel transporter system and conveyors, is exported to the surface. In coal mining at the excavation place, it must be taken into account the protection of the transporter from backfilling (Antunović Kobliška, 1963).

3.4.4. Analysis of application of modified pillar method production capacity of excavation unit

Production capacity is shown by the phases of the excavation, digging cycles, shifts, days and digs.

I excavation phase

Production by one blasting is:

$$P_1 = S_i \cdot l_n \cdot \gamma = 11.7 \cdot 1.0 \cdot 1.27 = 14.859t$$

So we have production from:

$$P_1 = 12.58 \text{ t/shift, relatively } 37.76 \text{ t/day.}$$

Excavation place of length of 35 m will be done (finished) in 41.32 shifts.

II excavation phase

Production from the excavation area of the opening excavation (OP-0) is approximately 156.39 tons. This production is received in four mining cycles and needed duration for this production is 4.594 shifts.

Production per cycle or shift from the excavation area is:

$$156.39/4 = 39.098 \text{ t/cycle}$$

$$156.39/4.594 = 34.04 \text{ t/shift}$$

Production from the first listed excavation area (OP-1) is approximately 255.92 tons. This production is received in four mining cycles and needed duration for this production is 6.411 shifts, so we have a production by cycle and by shift:

$$255.92/4 = 63.98 \text{ t/cycle}$$

$$255.92/6.411 = 39.92 \text{ t/shift}$$

III excavation phase

Production from the direction of the excavation upper dig and from excavation intersection is 221.3 tons, and is provided for 8 mining cycle and 6.19 shifts, so we have a production by cycle and by shift:

$$221.3/8 = 27.66 \text{ t/cycle}$$

$$221.3/6.19 = 35.75 \text{ t/shift}$$

Total production from a single excavation area is:

I excavation phase:

$$41.32 \text{ shifts} \times 12.58 \text{ t/shifts} = 519.8 \text{ t}$$

II excavation phase:

$$4.594 \text{ shifts} \times 34.04 \text{ t/shifts} = 156.39 \text{ t}$$

$$38.466 \text{ shifts} \times 39.92 \text{ t/shifts} = 1535.56 \text{ t}$$

III excavation phase

$$6.19 \text{ shifts} \times 35.75 \text{ t/shifts} = 221.3 \text{ t}$$

$$\text{TOTAL: } 91 \text{ shifts} \quad 2433.05 \text{ t}$$

The average production is:

$$2433.05/91 = 26.737 \text{ t/shift}$$

$$26.737 \times 3 = 80.21 \text{ t/day}$$

Within the geometry of the excavation balance coal reserves of 3403.54 tons are limited. During exploitation of one excavation 2496.94 tons is obtained, including coal from the basic preparation, or 73.36% of the available balance reserves.

PRODUCTION CAPACITY OF MINING FIELDS

In an excavation pillar at the coal seam successfully can work three pillar dig out with deep borehole mining in ringdrills, so production capacity will be:

The annual production of lane excavation pillar is:

$$3 \text{ excavation areas} \times 80.21 \text{ t/dig out per day} = 240.63 \text{ tons/day.}$$

$$30 \text{ days/month} \times 12 \text{ months} \times 240.63 \text{ tons/day} = 86626.8 \text{ t/year.}$$

Based on the above calculation has been shown that by the introduction of the modified pillar method, it is possible to increase annual coal production from the current 50000 tones to 86000 tones, and also is possible to increase the utilization of balance reserves from 55% to 73%.

4. CONCLUSION

In the ledge "Lubnica", thickness of coal layer is maximum 10.0 m, and there is a need for finding a solution of the digging method for digging powerful layers over 6.0 m, because existing methods are projected for coal layers of 5.0 m to 6.0 m of thickness. In these cases, at bringing down the coal from the roof part, with existing technology and deployment of mines, not all the coal from the upper digging place can be crashed down with only one blasting. Also, there is a need and a problem of entry of

workers in non-supported area of excavation place, so the remaining coal could be blasted.

In order to increase the efficiency of coal layer, to increase the safety of employees, as well as increasing effects, the introduction of a modified pillar method with fan-drilling and blasting with deep blast holes is proposed. By proposed modification of the existing pillar method, technical solutions that eliminate the current ban on entry into the digging area are given, because objectively there is no need for it.

Getting the upper digging part of coal layer is projected so as to be performed derogated in sections length 1.2 m to 1.5 m.

REFERENCES

- [1] ANTUNOVIĆ-KOBLIŠKA, M. (1963) *General mining works* (in Serbian). Belgrade: Institute for publishing textbooks of SR Serbia.
- [2] ANTUNOVIĆ-KOBLIŠKA, M. (1966) *Mechanics of rocks in mining, I and II part* (in Serbian). Belgrade: Faculty of Mining and Geology.
- [3] GENČIĆ, B. (1972) *Technological processes of underground exploitation of stratified deposits* (in Serbian). Belgrade: Institute for textbooks and teaching material.
- [4] GLUŠČEVIĆ, B. (1974) *Opening and underground ore deposits excavation* (in Serbian). Subotica: Minerva.
- [5] Technical documentation of the "Lubnica" mine.