UNDERGROUND MINING ENGINEERING 22 (2013) 7-13 UDK 62
FACULTY OF MINING AND GEOLOGY, BELGRADE YU ISSN 03542904

Professional paper

RECIPROCAL INFLUENCE OF MONORAIL DELIVERY OF ROW AND PROCESSED MATERIALS AND CROSS SECTION OF SUPPORTED UNDERGROUND CHAMBERS AT COAL MINES

MEĐUSOBNI UTICAJ JEDNOŠINSKE DOPREME REPROMATERIJALA I POPREČNOG PRESEKA PODGRAĐENIH PODZEMNIH PROSTORIJA U RUDNICIMA UGLJA

Ristović Ivica[1], Grujić Miodrag[2]

Abstract: During the process of mine transportation, delivery of row and processing materials has one of the key places in coal mining. In order to carry it out undisturbed, underground chambers must be prepared for this function. This paper points out the significance of reciprocal influence between monorail delivery of row and processing materials and cross section of underground chambers, through which the delivery of row and processing materials is being carried out, and the necessity for a complex analysis of this issue during the stage of designing

Key words: coal mines, underground chambers, delivery of row and processing materials

Apstrakt: U procesu rudničkog transporta doprema repromaterijala zauzima jedno od ključnih mesta u eksploaciji uglja. Da bi se ona mogla nesmetano obavljati, podzemne prostorije moraju biti osposobljene za ovu funkciju. U ovom radu se ukazuje na značaj međusobnog uticaja jednošinske dopreme repromaterijala i poprečnog preseka podzemnih prostorija kroz koje se vrši doprema repromaterijala i neophodnosti kompleksnog razmatranja ovog pitanja u fazi projektovanja.

Ključne reči: rudnici uglja, podzemne prostorije, doprema repromaterijala

1. INTRODUCTION

The delivery of row and processing materials at coal mines is very important, and without it, it is not possible to organize production, i.e. exploitation process. This issue is very complex and the more deep and indented the deposit is the more important it becomes. Costs of the delivery of row and processing materials become, at mines where this issue was being not addressed accordingly, higher and higher and they

[1] University of Belgrade, Faculty of Mining and Geology, Đušina 7, 11000 Belgrade, Serbia, e-mail: ivica@rgf.bg.ac.rs
[2] Assembly of the City of Belgrade, Dragoslava Jovanovića 2, 11000 Belgrade, Serbia, e-mail: miogru@yahoo.com

exceed fivefold value of basic transportation cost per mass unit. The important segment in the process of delivery of row and processing materials are also the underground chambers where the delivery is to be carried out. During the designing stage, those chambers also comply with the requirements of delivery, however in time their cross section changes and it represents limiting factor, it even disables the use of mechanized methods of excavation.

The purpose of this paper is to point out to the correlation between the change in cross section of underground chambers over time and monorail overhead delivery of row and processing materials. In the course of this, some solutions in connection with underground chambers and the delivery of row and processing materials are being examined as well.

2. BASIC POINTS OF THE DELIVERY OF ROW AND PROCESSING MATERIALS AT COAL MINES

Transportation of row and processing materials for coal mines may be carried out through various types of mine chambers. According to their purpose, those chambers may be service and multipurpose chambers. Service chambers are those constructed for the sole function of the delivery of row and processing materials, and multipurpose chambers represent the combination of different functions (transportation of excavated materials and transportation of manpower, delivery of row and processing materials and transportation of manpower and the like). Each chamber also serves for ventilation; they differ from each other only in the fact, if they convey fresh or used air current. The tendency of coal mines is to use mine chambers for several purposes wherever possible. Figure 1 shows the chamber for transportation of basic loads and delivery of row and processing materials (Grujić, 1995).

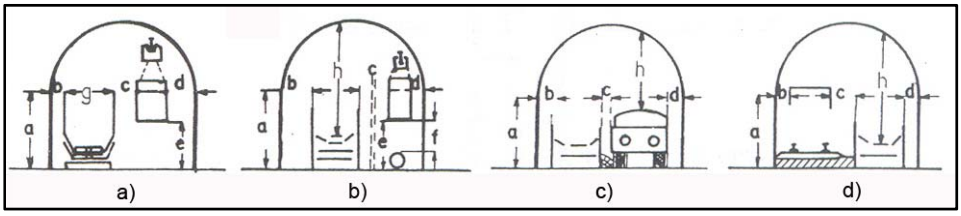

Figure 1 - Diagram of the cross section of chambers with equipment for basic load transportation and delivery of row and processing materials

The domination of continual exploitation technologies has resulted in dominant use of continual means of transportation for transportation of excavated material. This has caused drastic reduction in the usage of classical means for basic rail transportation, and therefore for the delivery of row and processing materials as well. Belt conveyors are not suitable for the delivery of row and processing materials, especially of sharp and undersized parts (Grujić, 1999).

Based on this, in the last 40 years, it came to the sudden development and usage of monorail overhead means for the delivery of row and processing materials at

coal mines. The advantages of monorail overhead means, apart from the possibility to be used in transportation chambers along with the equipment for transportation of excavated material, are also demonstrated in capability to overcome inclinations, which locomotives cannot do, in take-up of all types of freight, fast and easy mounting and possibility to be relocated onto other locations after completion of their function on previous site. The complexity of coal mines requires more and more the use of combined delivery of row and processing materials with reloading points. Monorail overhead delivery of row and processing materials is especially suitable for such type of transportation. For this purpose, special platforms and containers are being manufactured that can easily be reloaded from rail and non-rail vehicles onto monorail overhead means of transportation. Figure 2 displays diagram of technologies for reloading of containers from railway platforms onto monorail overhead means (a) and vice versa (b).

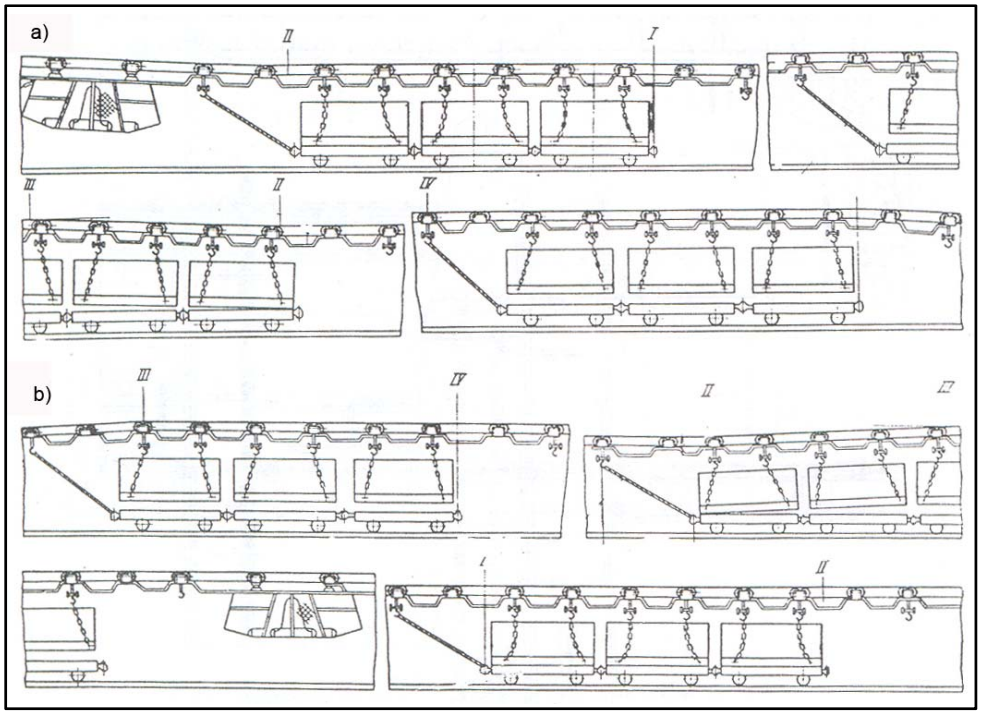

Figure 2 - Diagram of reloading of containers carrying row and processing materials

The organization of the delivery of row and processing materials is a very complex process and it requires full synchronization of all operations, as well as coordination with other organizational units. Regardless of the fact that monorail overhead means are placed in such a way that they do not disturb transportation means in carrying out the transportation of excavated material, the delivery of row and processing materials is, in general, carried out at the beginning of the shift for two reasons:

- timely supplying of working place with row and processing materials and
- non-disturbance of the main transport.

Organization of the delivery of row and processing materials also requires determination of time needed to carry out the delivery of row and processing materials and it can be displayed as follows:

$$T_{rp} = T_{sm} - \left(T_t - T_r\right) \tag{1}$$

whereby:
T_{sm} - duration of one shift,
T_t - time needed for transportation of material excavated during one shift,
T_r - time needed for transportation of manpower.

Actual time required for the delivery of row and processing materials depends on the quantity of the required row and processing materials, the length of transportation path, occurrence of undersized and long elements in row and processing materials etc. There are several ways to calculate row and processing materials required during one shift or one day, but all of them represent combination of computing and empiric methods.

3. MINE CHAMBERS AND THEIR CUSTOMIZATION FOR THE DELIVERY OF ROW AND PROCESSING MATERIALS

The delivery of row and processing materials is carried out through chambers supported differently. All types of support are present at coal mines, i.e. there are chambers without support, supported by anchors, as well as supported by wooden, steel, concrete, reinforced concrete, brick, combined and other support. At European mines the most present support is the steel one (75 - 95%), and at the coal mines in Serbia steel support is present with approximately 56%, wooden with 20% and concrete with approximately 16%, with approximately 8% of unsupported chambers (according to (Jovanović, 1994) - data from 1994.).

The delivery of row and processing materials by usage of monorail overhead means at coal mines in Serbia is much represented and it represents 70% of all methods for mechanized delivery. However, manual method for the delivery of row and processing materials, especially in the vicinity of working sites is still very present. The correlation between delivery of row and processing materials by using monorail overhead means of transportation and underground chambers, through which this delivery is carried out, is very significant, mainly in two aspects:

- the selection of profiles and support of underground chamber in function of the exploitation time;
- sizing of support as permanent structure of the means of delivery.

When designing underground chambers, it is necessary to take account of the fact that, due to pressures present in the pit, which is especially observable at coal mines, it comes to deformations and reduction of cross-section of underground chambers. In time, this reduction may be such, that it endangers basic functions of underground chambers. Reduction of cross section, in general, should be foreseen at the designing stage, and its evaluation should determine by how large surface the cross

section needs to be increased so that its function would not be endangered during exploitation (Milisavljević et al. 2012).

The reduction of cross section of underground chambers during the time of exploitation depends on many factors, the most important being: structural characteristics of rock mass, strength, deformability and the presence of fissures in rocks, the occurrence of fault, the shape of cross section of the camber, type of support, the size of profile, inclination of the chamber etc. Many authors dealt with this issue; however, the propositions for the solution were in the majority of cases based on empiric patterns with limited local significance. As the most acceptable evaluation of the requirement to increase surface of the cross section of the chamber S_{kom} depending on optimal requirement of the chamber's cross section S_{op}, time of the exploitation of the chamber t and annual reduction of chamber's cross section dS, could be determined for chambers to be supported by steel accessible support (Figure 3) by using the following pattern (Jovanović, 1994):

$$S_{kom} = S_{op} + t \cdot dS \tag{2}$$

Accessible steel support was proven at coal mines as very suitable, especially there, where overlaying rocks are light rocks. Its usage at mines in Serbia is significant.

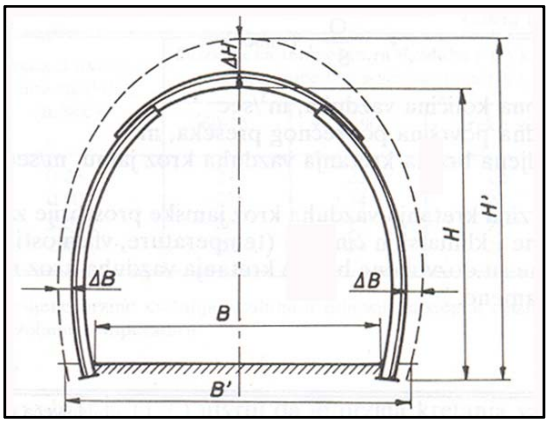

Figure 3 - Diagram of the accessible steel support with zones of deformation during exploitation

In the above pattern, the parameter dS represent constant which is invariable during the entire time of exploitation. It may be determined by the following formula, by using a large number of empiric coefficients (a, k_s, k_{sl}, k_z):

$$dS = \left(k_z \cdot a + k_z \cdot k_s \cdot S_{op} + k_z \cdot k_{sl} \cdot t_s\right) \Big/ \left(1 - k_s \cdot k_z\right) \tag{3}$$

In practice, it is very difficult to talk about constant annual reduction of chamber's cross section. Formula (3) takes into account, through different values of its coefficients for different qualities of rock mass, the alteration of the behavior of rocks also having a certain time dimension.

When delivering row and processing materials by monorail overhead means of transportation, it is necessary to hang the line (rail), upon which the freight is to be

moved, to the roof of the chamber, i.e. to the support located in the roof part, if the chamber is supported. Hanging of the bearer onto the support of the chamber is made by using chains at their joint, or at the part of bearer and it is to be carried out by using one or two chains. Hanging by using two chains may be carried out by placing chains onto the axis or orthogonal to the bearer's axis.

Bearers (rails) are usually made in lengths of 3 m, except in curves, where their length is from 0.5 to 1.0 m. Total load due to the weight of bearer and freight is transferred through chains or joints onto the support or the roof of underground chamber. At hanging of bearers by using two chains, placed orthogonal to the axis of the bearer, all loads are distributed to both chains, where tensile forces occur.

In order to size the support, upon which the rails for movement of means of transportation are to be hanged, it is necessary to determine forces at the ends of bearers that are transferred onto chains. In general, they may be determined by using formula:

$$A = B = P\left(l - x/l\right) \tag{4}$$

whereby:
P - concentrated force loading the bearer,
x - the distance between the load and the end of the bearer,
l - represents the length of the bearer.

The force P may be determined, if the heaviest element of the loaded articulated unit of monorail transportation mean that at one moment may be present on one bearer is known.

However, when transiting the line through curve at constant speed, due to the effect of centrifugal force, uneven loading occur. As the chain does not withstand the pressure, the function of one chain is lost, while the other chain assumes the entire load upon itself.

One of the methods to resolve this issue is to regulate the speed of load movement. The limitation of the speed of movement, at which both chains keep their function, may be calculated as follows (Grujić et al. 2012):

$$v_{doz} = \sqrt{g \cdot R \cdot \tan \alpha_1} \tag{5}$$

whereby:
R - radius of the curve,
α_1 - the angle formed by one chain in relation to the perpendicular axis.

Even load of chains is very important for transportation of heavy loads, because in case of large loading of one chain, it may break.

When designing and selecting the size of cross section as well as the support of the chamber, through which monorail overhead means of transportation are to be moved, it is necessary to take their potential impact on reduction of cross section during exploitation into account, as well. One of the methods to solve this issue is to reinforce support at points where hanging of the line elements is to be carried out.

4. CONCLUSION

For the purpose of undisturbed underground coal mining, it is necessary to provide timely servicing of a mine. It may be achieved, among other things, by reliable

delivery of row and processing materials. In order to carry out supplying of row and processing material successfully, transportation ways and mine chambers must be prepared for fulfillment of their basic function. When designing underground chambers it is necessary to take into account that their cross sections are changeable in time and that, apart from pressures present in the pit, their serviceability is affected by deformations due to the hanging of elements of monorail overhead means onto the support.

ACKNOWLEDGEMENT

This paper was realized as a part of the project "Research on possibility for AT (Advanced Technology) rockbolting application in mines for the purpose of increasing work safety and production efficiency" (TR 33025) financed by the Ministry of Education and Science of the Republic of Serbia within the framework of Programme of research in the field of technological development for the period 2011-2014.

REFERENCES

[1] GRUJIĆ, M. (1995) *Doprema repromaterijala i prevoz radnika u rudnicima*. Beograd: Rudarsko-geološki fakultet.

[2] GRUJIĆ, M. (1999) *Transport i izvoz u rudnicima*. Beograd: Rudarsko-geološki fakultet.

[3] GRUJIĆ, M. et al. (2012) Influence of Anchor Support of Underground Transportational Chambers on the Efficiency of the Supply of Intermediate Goods. In: *Proceedings of the 12th Conference Research and Development in Mechanical Industry RaDMI, Vol.2, Vrnjačka Banja, September 2012*. Vrnjačka Banja: Scientific and Technical Center for Intellectual Property Ltd., pp.986-989.

[4] JOVANOVIĆ, P. (1994) *Projektovanje i proračun podgrade horizontalnih podzemnih prostorija*. Beograd: Rudarsko-geološki fakultet.

[5] MILISAVLJEVIĆ, V. et al. (2012) Rockbolting Installation Trial in Soko Underground Coal Mine. In: *Proceedings of the 12th Conference Research and Development in Mechanical Industry RaDMI, Vol.2, Vrnjačka Banja, September 2012*. Vrnjačka Banja: Scientific and Technical Center for Intellectual Property Ltd., pp.1114-1118.