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SOME PROBLEMS OF EXTERNAL TRANSPORTATION OF RAW MATERIALS IN YUGOSLAV MINES

Summary. The working units and the objects for primary processing and exploiting raw materials are from couple hundred metres to tens of kilometres far from the mines. Organising transportation of raw materials is a complex problem in technical, economic and ecological sense. This paper deals with some issues of external transportation of raw materials in Yugoslav mines.

WYBRANE PROBLEMY TRANSPORTU ZEWNĘTRZNEGO SUROWCÓW W KOPALNIACH JUGOSŁAWII

Streszczenie. Zakłady i obiekty, w których następuje wstępna przeróbka surowców użytecznych, znajdują się kilkaset metrów do kilkunastu kilometrów od kopalni. Organizację transportu tych surowców należy rozwiązywać kompleksowo zarówno w sensie technicznym, ekonomicznym, jak i ekologicznym. W artykule przedstawiono wybrane zagadnienia dotyczące ww. tematyki w górnictwie Jugosławii.

Introduction

According to the records of the official services there has been registered 246 organizational systems dealing with exploitation and preparation of raw materials. It means, that 25 of them deals with exploitation of coal, 24 ones with metals, 191 with non-metals, and 6 of them with oil and gas.

Production of this systems brings from several thousand tons to many million tons a year. This production amount should be transported from mines to the objects for preparation and primary mineral raw processing, by various transportation means. The lengths of transportation routes can be many tens kilometers, which makes the organization difficult and increases the price of the raw materials.

This paper aims to point at the most important problems of external transportation of raw materials in Yugoslav mines. In addition to this, an outstanding attention has been paid to the problems connected with energy usage and environmental issues.

The most important questions of current state in mine external transportation

In Yugoslav mines external transportation of raw materials can be divided into:

1. external transportation as the extension of the internal one
2. independent external transportation

In the case of independent external transportation there is a question how to determine the difference between mine transportation and public transportation. As there are no limits concerning the length and transportation means, in case of Yugoslavia it has been accepted that the length of mine external transportation is limited in accordance with jurisdiction of each particular mine, what means that transportation is to be considered as mine external transportation as far as it is managed by the mine.

Analysis of external transportation in 183 mines exploiting various raw materials in Serbia has brought to the conclusion that average length is 8.29 km. The lengths of external transportation of particular raw materials are in table 1. It should be said that these ones are approximately real and that there is certain reservation because of unequal treatment of external transportation in various mine companies.

Table 1

Kind of raw materials	Number of observed mines	Average transportation length. km
coal	21	8,6
metal ores	18	10,8
stone	34	10,5
sand and gravel	18	3,8
clay	64	3,2
other	28	18,3

The most frequent problems that mines concerning external transportation of raw materials meet can be divided into four groups:

1. necessity of extension of tours
2. energy supplying
3. environmental protection
4. necessity of modernization.

Necessity of extension of tours come with the spreading of cavity fields and with the changing of point of transfer to external transportation means. This is particularly important in the case of open pit mines of non-metals and stationary transportation installations.

Energy supplying is one of the most serious problems appearing in many mines in the matter of external transportation. This question appears to be especially important in Yugoslav conditions, if we take into account well known difficulties in fuels supplying, if we take into account that track transportation is highly used.

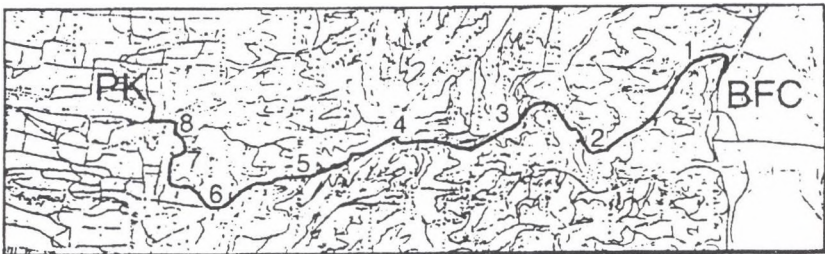
External transportation routes pass through all categories of environment, from national parks to urban settlement. Influence of transportation means and raw materials on environment is strong and it, very often, limits the application of some ways of transportation.

Characteristic of Yugoslav mines is quite long-lasting use of transportation systems and considerable amortization of transportation means. It can be said that most of external transportation means need some modernization, which is hardly feasible.

One of the most frequent ways of external transportation of raw materials is track transportation. It participates by 15% in external coal transportation, by 25% in transportation of metal ore and metal concentrate, while it participates in transportation of clay, stone, sand and gravel at the greatest extent, by 78%.

From mines to the objects for preparation and processing raw materials are transported by more than forty various types of tracks which can carry from 5 to 40 tons. There are very few of them which are not older than 5 years.

Beside the problem of energy supplying, one of the most important question that should be considered is environmental protection. There is a lot of noise while the track load moving, the dust rises, exhaust gases appear. Because of that, it is necessary to control the harmfulness being caused by truck transportation on some routes all the time. Here is the scheme of transportation route for the transportation raw materials for cement production by trucks through the National Park „Fruska gora” with the locations for observing the harmfulness in picture 1.



Picture 1. The route of truck transportation with marks
Rys.1. Schemat drogi transportowej wozami samojezdnymi

Rail external transportation is very used in transportation of coal, although this way of transportation is getting more and more replaced by track transportation or continual transportation. There is transportation of coal from big open pit mines to steam power plants. For that purpose, special wagons adjusted to disloading in the points in steam power plant are used. The problems appearing in that situation are connected with the organization and servicing of the objects and the equipment.

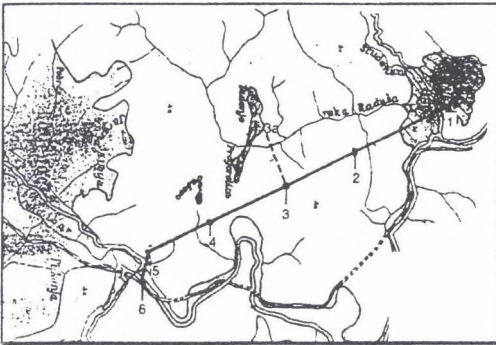
Railroad transportation of coal is very used in Yugoslavia and it covers from 750 to 800 million t-km. However, about 90% of these amounts are carried out by state railroad which manages its affairs with producers and consumers of coal on commercial bases.

In Yugoslav circumstances, out of territory of mine hydraulic transportation is most frequently applied for the transportation of concentrate and for dumping of waste. The basic problem appearing in this way of transportation is quite quick wearing out of pipes and pumps.

Transportation of grinded copper ore from open pit mine Cerovo-Cementacija to flotation in Bor is one of the longest hydraulic transportation systems. The length of the pipeline is 13.5 km long, radius of the pipe is 355 mm and the optimal capacity of $618 \text{ m}^3/\text{h}$ is carried out. The largeness of the ore being transported has the values smaller than 0.074 mm in about 70% cases.

External transportation by aerial ropeway was very used in previous phase of Yugoslav mining. However, for different reasons, often even unjustified, this way of transportation was pushed into background. At this moment, only about ten ropeways work, although there are some indications that they will be rehabilitated.

Here is the scheme of aerial ropeway in Ibar Coal Mines in picture 3. As the deposit Usce has been exhausted, and new deposit Tadenje has been opened, there are some projects of constructing new branch of the ropeway for transportation of coal.



Picture 3. Position of aerial ropeway in Ibar Coal Mines

Rys.3. Schemat usytuowania kolei linowej napowietrznej w kopalni Ibar

Described aerial ropeway has specific location of drive head station on the highest peak elevation of the toure. This solution enables very small energy usage, as maximal output of gravitational force during the moving of ropeway buckets.

Basic principles of the development of raw materials transportation

Considering the fact that external transportation is an important part of production of raw materials, it is necessary to take certain measures in Yugoslav mines in order to reduce operating costs. At this moment, two directions of the development of external transportation systems can be important:

- modernization of equipment for transportation and
- optimization of transportation with real capabilities.

As the modernization of external transportation concerns, it is adjustable in economic sense to introduce belt conveyors systems whereare it is possible in technical sense. During that, as the toures pass through environment it is necessary to protect it as much as possible.

Intensive development of specila belt conveyors has opened great opportunities for their application in external transportation of raw materials. It especially relates to high-angle conveyors and conveyors with closed bearing element. In Yugoslav conditions is expected that the pipe conveyors, sandwich conveyors and plants from Flexowell programs will soon find their application in external transportation.

Elimination of big number of trnshipment points in continual system is the most efficiently achieved by installing belt conveyors with horizontal curves. The advantage of this systems is the fact that the majority of parts and structures have the same construction as in the case of classic belt conveyors. Curve radius depends on resultant of forces acting in curve P_x , real tension in belt conveyor T and the length of arch of curve L_c , and it can be determined by using the next formula:

$$R_{min} = \frac{T + \sqrt{T^2 + 4P_x^2 \left(x - \frac{L_c}{2}\right)^2}}{2P_x}, \quad (2)$$

where x is the distance between the observed point and the beginning of curve.

Optimization of possible solutions of external transportation is to be done using also methods of multy-criterial analysis, beside the method of technical and economic analysis. The Department of Haulage and Hoisting at the Faculty of Mining and Geology in Belgrade applies successfully MATRIX and PROMETHEE methods for achieving optimal solutions.

In a general case the problem of a multi-criteria decision making can be defined in the following way:

$$\text{Max}\{k_1(a), k_2(a), \dots, k_p(a) | a \in A\} \quad (3)$$

Here K_1, K_2, \dots, K_p represent the criteria that had been previously chosen, whereas A is the ultimate set of available actions to be ranked in order to find an optimal solution.

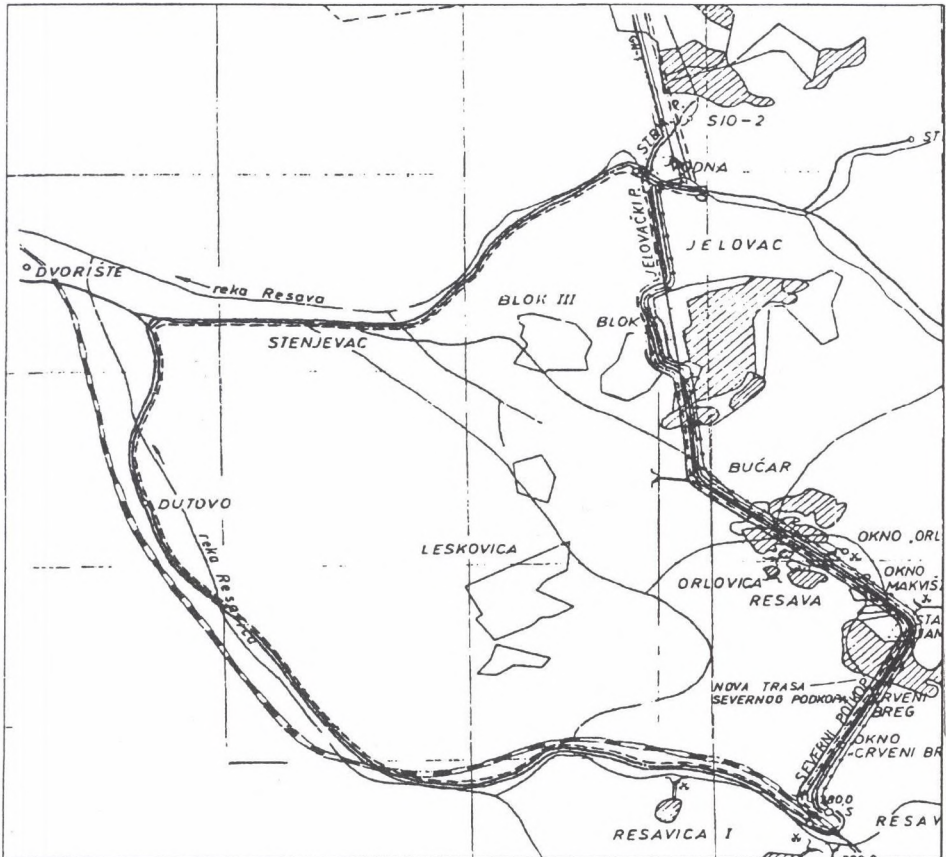
The biggest problem in a multi-criteria analysis, no matter which analysis is in question, is determination of a quantifying parameter, that is, determination of the relationship between individual parameters. In external transportation of mineral materials the most important criteria would be the following:

- a) specific transportation costs;
- b) amount of initial investments;
- c) necessary labour
- d) supply of energy
- e) possibility of automation;
- f) safety and reliability of the system;
- g) protection of the living environment.

One of the most important tasks in all the methods of a multi-criteria analysis is determination of the coefficient of weight defining the degree of the effect of each criterion. Each transportation system must satisfy the following condition:

$$\sum_{k=1}^p \omega_k = 1 \quad (4)$$

The choice of optimal external transportation from Strmosten shaft and Jelovac shaft at Rembas mine (picture 4) is characteristic example of application of multi-criterial analysis. In this case six variants of transportation of coal to separation has been considered.



Picture 4. Schem of transportation variants in Rembas mine

Rys.4. Schemat wariantów transportu w kopalni Rembas

The following criteria have been used: specific transportation costs, extent of investments, number of employees, environmental protection and the extent of crushing of coal in transportation. In this example MATRIX method and PROMETHEE method have been used and the optimal solution that has been reached is the same in both cases: combined transportation by belt conveyors and tracks.

Conclusion

Big length and specificities of raw materials in external transportation require the full attention paid to this question. Many problems that appear in that case influence the efficiency of work of system. Because of that, it is necessary to eliminate such problems, in the first place those of them which are connected with reliability of work, energy usage, environmental protection, etc. Also, it is necessary to apply multy-criterial methods of making decision in process of choosing way of external transportation, as there are many factors that influence the work of these systems.

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Omówienie

Zakłady i obiekty, w których następuje wstępna przeróbka surowców użytecznych, znajdują się kilkaset metrów do kilkunastu kilometrów od kopalni. Organizację transportu tych surowców należy rozwiązywać kompleksowo zarówno w sensie technicznym, ekonomicznym, jak i ekologicznym. W artykule przedstawiono wybrane zagadnienia dotyczące ww. tematyki w górnictwie Jugosławii. Duże długości dróg transportowych i specyfika surowców odpadowych wymagają, aby na ten problem zwrócono większą uwagę, ponieważ wpływa on na pracę całego układu kopalnia-zakład wzbogacania. Należy stosować wielokryterialne metody pozwalające na podjęcie właściwych decyzji.