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POSSIBILITY OF APPLYING THE MULTICRITERIA ANALYSIS METHOD WHEN SELECTING A CONVEYANCE SYSTEM IN A LEAD AND ZINC MINE

MOGUĆNOST PRIMENE METODA VŠEKRITERIJUMSKE ANALIZE PRI IZBORU TRANSPORTNOG SISTEMA U RUDNIKU OLOVA I CINKA

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Abstract: *High costs of conveyance, as well as the need of taking into account other criteria, impose the application of other modern methods when selecting an optimal conveyance system in mines. This problem is especially obvious in metallic mineral raw materials mines. This Paper deals with possibilities of applying the multi-criteria analysis method when selecting an optimal conveyance system in a lead and zinc mine.*

Key words: *metallic mineral, modern methods, conveyance system*

Apstrakt: *Visoki troškovi transporta, kao i neophodnost uzimanja u obzir i drugih kriterijuma, diktiraju primenu drugih savremenih metoda, za izbor optimalnog načina transporta u rudnicima. Ovaj problem je naročito izražen u rudnicima metaličnih mineralnih sirovina. U ovom radu su obrađene mogućnosti primene metode višekriterijumske analize pri izboru optimalnog transportnog sistema u jednom rudniku olova i cinka.*

Ključne reči: *metalične mineralne sirovine, savremene metode, transportni sistem*

1 INTRODUCTION

Mining of metallic mineral raw materials is made through the discontinuous system, which includes cyclic transport. Disadvantages of discontinuous conveyance (generally the locomotive transportation) in main conveyance premises (transportnim prostorijama) led to the more frequent replacement of this conveyance system by continuous belt conveyance system. Former disadvantages of conveyor belts (abrasion sensitivity, a large number of conveyors in the system, emergence of lines in a curve, grading of material etc.) are moderated or removed; therefore at the moment, in a considerable number of metal mines, continuous conveyance systems are applied.

1. UVOD

Eksploatacija metaličnih mineralnih sirovina se uglavnom vrši diskontinualnim načinom, što je podrazumevalo i ciklični transport. Nedostaci diskontinualnog transporta (najčešće lokomotivskog) u glavnim transportnim prostorijama, doveli su do toga da se sve češće vrši njegova zamena kontinualnim transportnim sistemom sa trakama. Raniji nedostaci transportnih traka (osetljivost na abraziju, veći broj transportera u sistemu, pojava trasa u krivini, granulacija materijala i dr.), se ublažavaju ili otklanjaju, tako da u značajnom broju rudnika metala, u ovom trenutku, egzistiraju kontinualni transportni sistemi.

A large number of metal mines plans to replace the locomotive conveyance system with the belt conveyance system. As there is a number of belt conveyance variants which should be compared to the current conveyance system, it is necessary to find an optimal solution. Technical-economic analysis gives good parameters, but it is not sufficient, and therefore it is necessary to undertake the multi-criteria analysis.

The objective of this Paper is to show basic postulates of the multi-criteria decision-making (PROMETHEE method) in selecting an optimal conveyance system in a metal mine. The Paper also provides with an example of the solution of this issue in the Lead and Zinc Mine Zletovo (Former Republic of Yugoslavia Macedonia).

Veliki broj rudnika metala planira da izvrši zamenu lokomotivskog transporta sistemom sa trakama. Pošto postoji veći broj varijanti sa trakama, koje treba uporediti sa postojećim načinom transporta, neophodno je naći optimalno rešenje. Tehničko-ekonomska analiza daje dobre pokazatelje, ali nije dovoljna, pa stoga treba pristupiti višekriterijumskoj analizi.

Cilj ovog rada je da prikaže osnovne postavke višekriterijumskog načina odlučivanja (metoda PROMETHEE) kod izbora optimalnog transportnog sistema u rudniku metala. Pri tome se daje primer rešenja ovog problema u rudniku olova i cinka Zletovo (Republika Makedonija).

2 APPLICATION OF THE MULTI-CRITERIA ANALYSIS METHOD WHEN SELECTING A CONVEYANCE SYSTEM IN THE ZLETOVO MINE

Generally, when selecting a conveyance system, the usual procedure is to search for a solution by considering various variants. The most frequently applied selection methods are based on the technical-economic and multi-criteria analysis. In the case the multi-criteria decision-making is applied, the results of the technical-economic analysis (specific costs) are treated as one of the criteria.

Multi-criteria analysis includes a number of criteria having more or less influence on the selection of the most adequate variant of conveyance. In mine conveyance, the following criteria are considered as the most important:

- Specific costs of conveyance,
- Amount of initial investments,
- Structure of the man power,
- Safety at work,
- System reliability,
- Possibility of automatization,
- Environmental protection and other.

A general issue in multi-criteria decision-making may be presented in the following way:

If k_1, k_2, ..., kp are the criteria which were previously selected, while A is the final set of

2 PRIMENA METODE VIŠEKRITERIJUMSKE ANALIZE PRI IZBORU TRANSPORTNOG SISTEMA U RUDNIKU ZLETOVO

Kod izbora načina transporta, u opštem slučaju, uobičajeni je postupak da se rešenje traži razmatranjem više varijanti. Najčešće primenjivane metode izbora baziraju se na tehničko-ekonomskoj i višekriterijumskoj analizi. U slučaju primene višekriterijumskog odlučivanja rezultati tehničko-ekonomske analize (specifični troškovi) imaju tretman jednog od kriterijuma.

Višekriterijumska analiza obuhvata više kriterijuma koji imaju veći ili manji uticaj na izbor najpovoljnije varijante transporta. Kod rudničkog transporta kao najvažniji kriterijumi se mogu smatrati:

- specifični troškovi transporta,
- visina početnih investicija,
- struktura radne snage,
- sigurnost pri radu,
- pouzdanost sistema,
- mogućnost automatizacije,
- zaštita životne sredine i dr.

Opšti problem višekriterijumskog odlučivanja se može predstaviti na sledeći način:

Ako su k_1, k_2, ..., kp kriterijumi koji su prethodno izabrani, dok je A konačan skup available actions (variants) that are to be ranked, this problem may be expressed as follows:

$$\text{Max} \{ k_1(a), k_2(a), \dots k_p(a) \mid a \in A \} \quad (1)$$

Table 1, consisting of attributes k_i (a_i), where $a_i \in A$, may be used for displaying necessary information.

raspoloživih akcija (varijanti) koje treba rangirati, ovaj problem se može predstaviti sledećim izrazom:

$$\text{Max} \{ k_1(a), k_2(a), \dots k_p(a) \mid a \in A \} \quad (1)$$

Za prikazivanje potrebnih podataka može se iskoristiti tabela 1 koja se sastoji od atributa k_i (a_i), gde $a_i \in A$.

Table 1
Tabela 1

	$K_1 (\cdot)$	$K_2 (\cdot)$	...	$K_i (\cdot)$	...	$K_p (\cdot)$
a_1	$K_1 (a_1)$	$K_2 (a_1)$	...	$K_i (a_1)$	...	$K_p (a_1)$
a_2	$K_1 (a_2)$	$K_2 (a_2)$	...	$K_i (a_2)$	...	$K_p (a_2)$
...	...	...	...	...	...	...
a_i	$K_1 (a_i)$	$K_2 (a_i)$	...	$K_i (a_i)$	...	$K_p (a_i)$
...	...	...	...	...	...	...
a_n	$K_1 (a_1)$	$K_2 (a_n)$	...	$K_i (a_n)$	...	$K_p (a_n)$

The procedure for applying the PROMETHEE method consists of the following three steps, although some versions of this method envisage 4 stages:

- Generalization of each criterion,
- Defining the preference index,
- Decision-making.

Possibilities of applying this method are illustrated by the example of the Lead and Zinc Mine Zletovo. In that matter, parameters of the conveyance from the period when the mine operated at full capacity were used, while taking into account the perspective for further increase in production.

Ore conveyance in the Zletovo Mine in Macedonia is made in such a way that the ore is transported, by wagons, from block ore bars to bunkers at the haulage shaft No. 1. The ore is then being transported to the main haulage tunnel (GIP) Probištip-Dobrevo where it is further transported, using locomotive conveyance, to the flotation in Probištip. Diagram of ore conveyance and haulage is shown in the Figure 1.

Problems which occur in locomotive conveyance through the main winch incline imposed a need for developing a technical documentation related to the introduction of continuous belt conveyance system. The elementary input data for resolving this problem are as follows:

Postupak primene metode PROMETHEE se sastoji od sledeća tri koraka, mada neke verzije ove metode predviđaju 4 faze:

- uopštavanje svakog kriterijuma,
- određivanje indeksa preferencije,
- donošenje odluke.

Mogućnosti primene ove metode prikazane su na primeru rudnika olova i cinka Zletovo. Pri tome su korišćeni parametri transporta iz perioda kada je rudnik radio punim kapacitetom, uz uzimanje u obzir perspektive daljeg povećanja proizvodnje.

Transport rude u rudniku Zletovo u Makedoniji se obavlja tako što se ruda od blokovskih rudnih sipki transportuje vagonima do centralnih rudnih sipki, a od njih lokomotivama i vagonima do bunkera na izvoznom oknu br. 1. Izvoz rude se dalje vrši do glavnog izvoznog potkopa (GIP) Probištip-Dobrevo gde se dalje uz primenu lokomotivskog transporta vozi do flotacije u Probištipu. Šema transporta i izvoza rude je prikazana na slici 1.

Problemi koji se javljaju pri lokomotivskom transportu kroz glavni izvozni niskop, nametnuli su potrebu da se pristupi izradi tehničke dokumentacije za uvođenje kontinualnog transportnog sistema sa trakama. Osnovni ulazni podaci za rešavanje ovog problema su sledeći:

- Conveyance length L = 3426 m
- Conveyance annual capacity Q_g = 600 000 t/god
- Average line slope p =3
- Volumetric mass of loose ore $\gamma_n = 1{,}8$ t/m^3

- dužina transporta L = 3426 m
- godišnji kapacitet transporta Q_g = 600 000 t/god
- prosečan nagib trase p =3
- zapreminska masa rastresite rude $\gamma_n = 1{,}8$ t/m^3

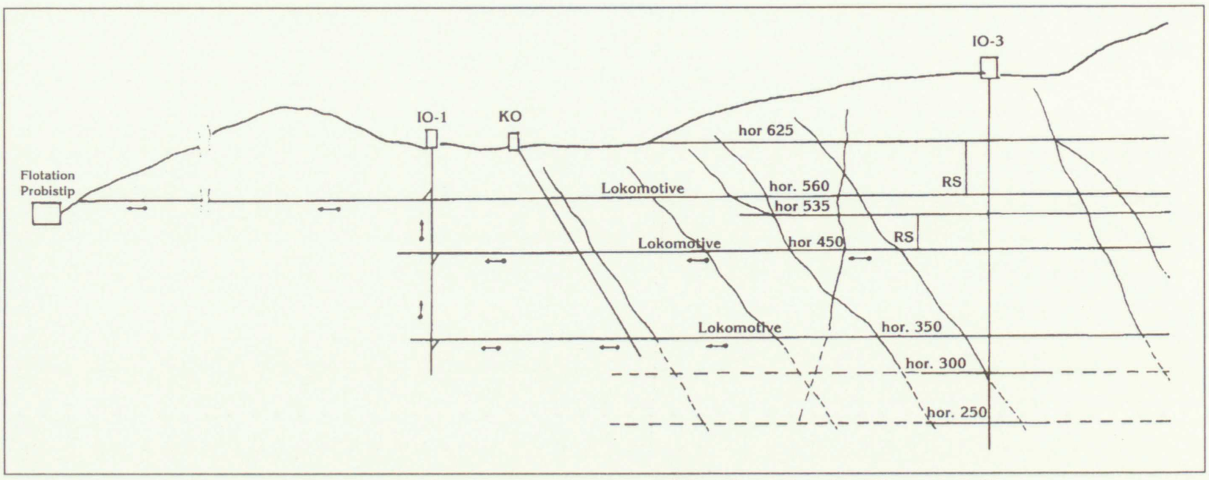

Figure 1 Diagram of ore conveyance and haulage in the Zletovo Mine
slika 1 Šema transporta i izvoza u rudniku Zletovo

In selecting an optimal solution the following 5 variants were considered:

- Current locomotive conveyance (trolley locomotives) – a_1
- Variant with accumulator locomotives – a_2
- Variant with 6 belt conveyors – a_3
- Variant with 4 conveyors (one with 2 curves) – a_4
- Variant with 1 conveyor with 4 curves – a_5

The following criteria for selecting an optimal conveyance system using the PROMETHEE method were:

K_1 – specific costs of conveyance in $/t (min),
K_2 – amount of total investments in $ (min),
K_3 – necessary number of workers (min),
K_4 – safety in working on conveyance (max),
K_5 – atmosphere pollution (min),
K_6 – system reliability (max),
K_7 – possibility of system automatization (max).

The values of weight coefficients were obtained after making analysis of similar systems in the region and in Europe and they amount to (according to the criteria order): ω_k = [0,35 0,10 0,10 0,13 0,12 0,10 0,10].

The above variants are developed in the technical-economic analysis in order to obtain

Za izbor optimalnog rešenja razmatrano je 5 varijanti i to:

- postojeći lokomotivski transport (trolne lokomotive) – a_1
- varijanta sa akumulatorskim lokomotivama – a_2
- varijanta sa 6 trakastih transportera – a_3
- varijanta sa 4 transportera (jedan sa dve krivine) – a_4
- varijanta sa 1 transporterom sa 4 krivine – a_5

Kao kriterijumi za izbor optimalnog načina transporta pomoću metode PROMETHEE su izabrani:

K_1 – specifični troškovi transporta u $/t (min),
K_2 – veličina ukupnih investicija u $ (min),
K_3 – potreban broj radnika (min),
K_4 – bezbednost rada na transportu (max),
K_5 – zagađivanje atmosfere (min),
K_6 – pouzdanost sistema (max),
K_7 – mogućnosti automatizacije sistema (max).

Vrednosti težinskih koeficijenata su dobijene posle analize sličnih sistema u regionu i u Evropi i oni iznose (prema redosledu kriterijuma): ω_k = [0,35 0,10 0,10 0,13 0,12 0,10 0,10].

Navedene varijante su obrađene tehničko-ekonomskom analizom da bi se dobile veličine values K_1 and K_2. The overview of technical and economic parameters for locomotive conveyance is given in the Table 2:

K_1 i K_2. U tabeli 2 dat je prikaz tehničko-ekonomskih parametara za lokomotivski transport:

Table 2
Tabela 2

Parameters	Variantes	
	a_1	a_2
Mass of a locomotive, t	11	15
Volume of a wagon, m^3	2,5	4
Number of wagons in a train	24	22
required number of trains	3	2
Required number of workers	42	39
Total investments, $	1.728.056	1.767.097
Specific costs of conveyance, $/t	1,72	1,73

For belt conveyors variants, parameters adopted in the course of technical-economic analysis of these variants are given in the Table 3. As for GIP Zletovo mine, stationary belt conveyors were envisaged to be applied.

Za varijante sa transporterima sa trakom u tabeli 3 dati su parametri koji su usvojeni u toku tehničko-ekonomske analize ovih varijanti. Za primenu u GIP rudnika Zletovo predviđeni su stacionarni transporteri sa trakom.

Table 3
Tabela 3

Parameters	Variantes		
	a_3	a_4	a_5
Number of conveyors	6	4	1
Conveyor length, m	260	2492	3426
	380	662	
	1852	200	
	662	72	
	200		
	72		
Belt width, mm	800	800	1000
Belt type	EP 1000/4	EP 1250/3	EP 1400/5
		EP 1000/4	
Movement speed, m/s	2,12	2,12	2,12
Belt capacity, t/h	649	649	1058
Required motor power, kW	22	149	237
	29	45	
	111	18	
	45	9	
	18	-	
	9	-	
Required number of workers	31	26	18
Total investments, $	2.743.990	2.070.069	3.303.934
Specific costs of conveyance, $/t	2,20	2,07	2,15

Figure 2 gives a schematic overview of three variants with continuous conveyance through main haulage tunnel of the Zletovo mine. In this overview it is obvious that there are curves in horizontal plane in the current tunnel, which resulted in the analysis of three variants: with 6 rectilinear conveyors, with 3 rectilinear and 1 curvilinear and with only 1 conveyor having 4 curves in horizontal plane.

Na slici 2 dat je šematski prikaz tri varijante sa kontinualnim transportom kroz glavni izvozni potkop rudnika Zletovo. Iz ove šeme se može videti da u postojećem potkopu postoje krivine u horizontalnoj ravni, što je uslovilo analizu tri varijante: sa 6 pravolinijskih transportera, sa 3 pravolinijska i jednim krivolinijskim i samo sa jednim transporterom koji ima četiri krivine u horizontalnoj ravni.

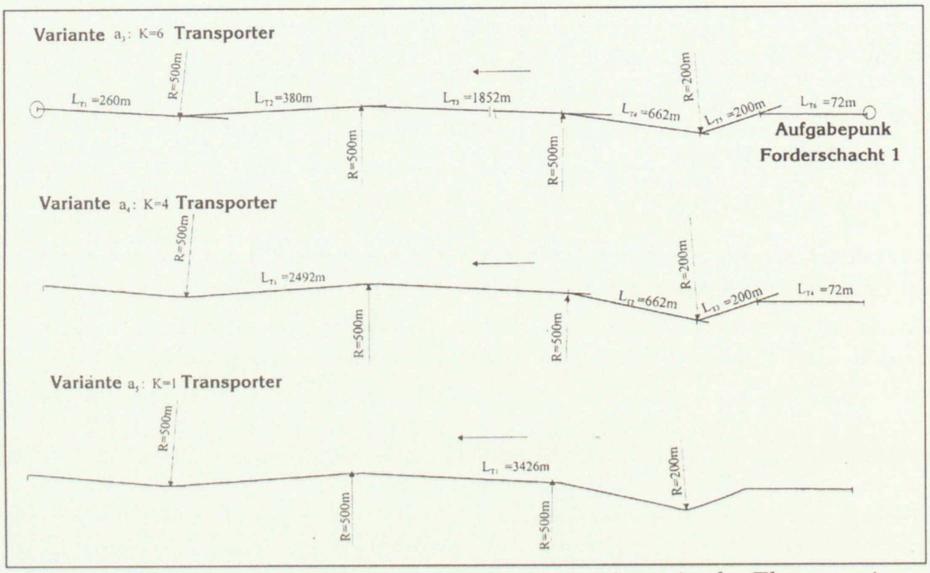

Figure 2 Overview of continuous conveyance variants in the Zletovo mine
slika 2 Šema varijanti kontinualnog transporta u rudniku Zletovo

Table 4 gives variants (actions) and criteria for multi-criteria selection of an optimal conveyance in GIP.

U tabeli 4 su date varijante (akcije) i kriterijumi za višekriterijumski izbor optimalnog transporta u GIP.

Table 4
Tabela 4

	K_1	K_2	K_3	K_4	K_5	K_6	K_7
min/max	min	min	min	max	min	max	max
a_1	2.53	2.541	42	3	7	3	5
a_2	2.55	2.599	39	5	7	3	3
a_3	3.23	4.035	31	7	5	5	7
a_4	3.04	4.070	26	7	5	7	7
a_5	3.17	4.859	18	9	3	9	9
Type of individual criteria,	Linear (III)	Linear (III)	Linear (III)	Gradual (IV)	Gradual (IV)	Linear (III)	Linear (III)
Parameter							
m	-	-	-	2	2	-	-
n	0.7	2.3	2.4	4	4	6	6
Weight	0.35	0.10	0.13	0.12	0.10	0.10	0.10

Values of the preference function for each action, i.e. variant of continuous conveyance, are given in the Table 5.

Vrednosti funkcije preferencije za svaku akciju, odnosno varijantu kontinualnog transporta date su u tabeli 5.

Table 5
Tabela 5

$P_1(a_1,a_2) = 0.029$	$P_1(a_1,a_3) = 1$	$P_1(a_1,a_4) = 0.729$	$P_1(a_1,a_5) = 0.914$
$P_2(a_1,a_2) = 0.025$	$P_2(a_1,a_3) = 0.650$	$P_2(a_1,a_4) = 0.665$	$P_2(a_1,a_5) = 1$
$P_3(a_1,a_2) = 0$	$P_3(a_1,a_3) = 0$	$P_3(a_1,a_4) = 0$	$P_3(a_1,a_5) = 0$
$P_4(a_1,a_2) = 0$	$P_4(a_1,a_3) = 0$	$P_4(a_1,a_4) = 0$	$P_4(a_1,a_5) = 0$
$P_5(a_1,a_2) = 0$	$P_5(a_1,a_3) = 0$	$P_5(a_1,a_4) = 0$	$P_5(a_1,a_5) = 0$
$P_6(a_1,a_2) = 0$	$P_6(a_1,a_3) = 0$	$P_6(a_1,a_4) = 0$	$P_6(a_1,a_5) = 0$
$P_7(a_1,a_2) = 0$	$P_7(a_1,a_3) = 0$	$P_7(a_1,a_4) = 0$	$P_7(a_1,a_5) = 0$
$P_1(a_2,a_1) = 0$	$P_1(a_2,a_3) = 0.971$	$P_1(a_2,a_4) = 0.700$	$P_1(a_2,a_5) = 0.886$
$P_2(a_2,a_1) = 0$	$P_2(a_2,a_3) = 0.624$	$P_2(a_2,a_4) = 0.640$	$P_2(a_2,a_5) = 0.983$
$P_3(a_2,a_1) = 0.125$	$P_3(a_2,a_3) = 0$	$P_3(a_2,a_4) = 0$	$P_3(a_2,a_5) = 0$
$P_4(a_2,a_1) = 0$	$P_4(a_2,a_3) = 0$	$P_4(a_2,a_4) = 0$	$P_4(a_2,a_5) = 0$
$P_5(a_2,a_1) = 0$	$P_5(a_2,a_3) = 0$	$P_5(a_2,a_4) = 0$	$P_5(a_2,a_5) = 0$
$P_6(a_2,a_1) = 0$	$P_6(a_2,a_3) = 0$	$P_6(a_2,a_4) = 0$	$P_6(a_2,a_5) = 0$
$P_7(a_2,a_1) = 0$	$P_7(a_2,a_3) = 0$	$P_7(a_2,a_4) = 0$	$P_7(a_2,a_5) = 0$
$P_1(a_3,a_1) = 0$	$P_1(a_3,a_2) = 0$	$P_1(a_3,a_4) = 0$	$P_1(a_3,a_5) = 0$
$P_2(a_3,a_1) = 0$	$P_2(a_3,a_2) = 0$	$P_2(a_3,a_4) = 0.015$	$P_2(a_3,a_5) = 0.358$
$P_3(a_3,a_1) = 0.458$	$P_3(a_3,a_2) = 0.333$	$P_3(a_3,a_4) = 0$	$P_3(a_3,a_5) = 0$
$P_4(a_3,a_1) = 0.5$	$P_4(a_3,a_2) = 0.500$	$P_4(a_3,a_4) = 0$	$P_4(a_3,a_5) = 0$
$P_5(a_3,a_1) = 0$	$P_5(a_3,a_2) = 0$	$P_5(a_3,a_4) = 0$	$P_5(a_3,a_5) = 0$
$P_6(a_3,a_1) = 0.333$	$P_6(a_3,a_2) = 0.333$	$P_6(a_3,a_4) = 0$	$P_6(a_3,a_5) = 0$
$P_7(a_3,a_1) = 0.667$	$P_7(a_3,a_2) = 0.667$	$P_7(a_3,a_4) = 0$	$P_7(a_3,a_5) = 0$
$P_1(a_4,a_1) = 0$	$P_1(a_4,a_2) = 0$	$P_1(a_4,a_3) = 0.271$	$P_1(a_4,a_5) = 0.186$
$P_2(a_4,a_1) = 0$	$P_2(a_4,a_2) = 0$	$P_2(a_4,a_3) = 0$	$P_2(a_4,a_5) = 0.343$
$P_3(a_4,a_1) = 0667$	$P_3(a_4,a_2) = 0.542$	$P_3(a_4,a_3) = 0.208$	$P_3(a_4,a_5) = 0$
$P_4(a_4,a_1) = 0.5$	$P_4(a_4,a_2) = 0.5$	$P_4(a_4,a_3) = 0$	$P_4(a_4,a_5) = 0$
$P_5(a_4,a_1) = 0$	$P_5(a_4,a_2) = 0$	$P_5(a_4,a_3) = 0$	$P_5(a_4,a_5) = 0$
$P_6(a_4,a_1) = 0.667$	$P_6(a_4,a_2) = 0.667$	$P_6(a_4,a_3) = 0.333$	$P_6(a_4,a_5) = 0$
$P_7(a_4,a_1) = 0.667$	$P_7(a_4,a_2) = 0.667$	$P_7(a_4,a_3) = 0$	$P_7(a_4,a_5) = 0$
$P_1(a_5,a_1) = 0$	$P_1(a_5,a_2) = 0$	$P_1(a_5,a_3) = 0.086$	$P_1(a_5,a_4) = 0$
$P_2(a_5,a_1) = 0$	$P_2(a_5,a_2) = 0$	$P_2(a_5,a_3) = 0$	$P_2(a_5,a_4) = 0$
$P_3(a_5,a_1) = 1$	$P_3(a_5,a_2) = 0.875$	$P_3(a_5,a_3) = 0.542$	$P_3(a_5,a_4) = 0.333$
$P_4(a_5,a_1) = 1$	$P_4(a_5,a_2) = 1$	$P_4(a_5,a_3) = 0$	$P_4(a_5,a_4) = 0$
$P_5(a_5,a_1) = 0.5$	$P_5(a_5,a_2) = 0.5$	$P_5(a_5,a_3) = 0$	$P_5(a_5,a_4) = 0$
$P_6(a_5,a_1) = 1$	$P_6(a_5,a_2) = 1$	$P_6(a_5,a_3) = 0.667$	$P_6(a_5,a_4) = 0.333$
$P_7(a_5,a_1) = 1$	$P_7(a_5,a_2) = 1$	$P_7(a_5,a_3) = 0.333$	$P_7(a_5,a_4) = 0.333$

On the basis of values of preference functions shown in Table 5, preference indexes were calculated, which enable defining input, output and pure flow rates of individual alternatives. Values of the preference index, input-output and pure flow rates are given in Table 6.

Na osnovu vrednosti funkcija preferencije prikazanih u tabeli 5 izračunati su indeksi preferencije koji omogućuju da se odrede ulazni, izlazni i čisti protoci pojedinih alternativa. Vrednosti indeksa preferencije, ulazno-izlaznih i čistih protoka dati su u tabeli 6.

Table 6
Tabela 6

	a_1	a_2	a_3	a_4	a_5	T^+	T
a_1	0	0.013	0.415	0.321	0.420	0.292	0.047
a_2	0.012	0	0.402	0.309	0.408	0.283	0.048
a_3	0.211	0.198	0	0.000	0.036	0.117	-0.171
a_4	0.265	0.253	0.149	0	0.099	0.191	0.008
a_5	0.490	0.482	0.184	0.099	0	0.313	**0.072**
T	0.245	0.235	0.288	0.183	0.241		

Obtained values of pure flow rates enable ranking the variants which is shown in Table 7.

Dobijene vrednosti čistih protoka omogućava rangiranje varijanti koje je prikazano u tabeli 7.

Table 7
Tabela 7

	T	Ranking
a_5	0.072	1
a_2	0.048	2
a_1	0.047	3
a_4	0.008	4
a_3	-0.171	5

From the table above it is obvious that the optimal solution is the variant a_5, which has the highest value of pure flow rate. Therefore, we may state that the most suitable variant for ore conveyance through main haulage tunnel is the one that envisages one conveyor with four curves in horizontal plane. Using matrix method, the verification was made for the same variants and the same criteria, and the variant a_5 was also adopted as the most suitable one. By means of a standard technical-economic analysis, this variant would be ranked as forth, which tell us that it is necessary to take into account a number of criteria in decision-making.

Iz prethodne tabele se može videti da je optimalno rešenje varijanta a_5, koja ima najveću vrednost čistog protoka. Prema tome može se konstatovati da je najpovoljnija varijanta transporta rude kroz glavni izvozni potkop ona koja predviđa jedan transporter sa četiri krivine u horizontalnoj ravni. Izvršena je provera pomoću matrične metode, sa istim varijantama i sa istim kriterijumima, i takođe je kao najpovoljnija usvojena varijanta a_5. Standardnom tehničko-ekonomskom analizom ova varijanta bi bila tek četvrta, što govori o neophodnosti uzimanja u obzir više kriterijuma prilikom odlučivanja.

3 CONCLUSION

Conveyance of solid mineral raw materials represents a complex process in every mine. Metal mines, in order to improve operation efficiency, undertake introducing continuous conveyance systems. In that matter, it is necessary to select an optimal solution, taking into account a number of criteria. Modern multi-criteria methods give the possibility of a simple application when selecting an optimal conveyance system. It is also necessary to carefully select criteria and to define their weight coefficient in an adequate way.

3 ZAKLJUČAK

Transport čvrstih mineralnih sirovina predstavlja složen proces u svakom rudniku. Rudnici metala, u cilju povećanja efikasnosti rada, pristupaju uvođenju kontinualnih transportnih sistema. Pri tome je neophodno izabrati optimalno rešenje uzimajući u obzir više kriterijuma. Savremene višekriterijumske metode pružaju mogućnost jednostavne primene pri izboru optimalnog načina transporta. Pri tome je neophodno da se pažljivo izaberu kriterijumi i pravilno odrede njihovi težinski koeficijenti.

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