ZESZYTY NAUKOWE POLITECHNIKI ŚLĄSKIEJ 2000
Seria: GÓRNICTWO z. 246 Nr kol. 1480

Miloš MILIČIĆ, Vojin ČOKORILO
Faculty of Mining and Geology, Belgrade, Yugoslavi

MINING EQUIPMENT EVALUATION AND SELECTION BASED ON TECHNICAL CHARACTERISTICS

Summary. This paper reviews the method for evaluation of mining machines based on their technical characteristics (parameters). This method can be applied to the arbitrary number of machines with arbitrary number of technical characteristics (parameters).

OCENA I WYBÓR URZĄDZEŃ GÓRNICZYCH NA PODSTAWIE ICH CHARAKTERYSTYK TECHNICZNYCH

Streszczenie. Artykuł omawia metodę oceny maszyn górniczych na podstawie charakterystyki technicznej (parametry). Metoda ta może być zastosowana dla dowolnej liczby urzadzeń górniczych z dowolną ilością parametrów technicznych.

Introduction

Selection of mining machines for given working conditions depends on numerous factors, such as: technical, economic, ergonomic etc. Results of the machine evaluation based on their technical characteristics together with above mentioned influences are combined with economical evaluation of purchase and achievement of maximum effectiveness in given working conditions. Every manufacturer supplies technical characteristics of his products. Basing on these characteristics, buyer of the machine will conclude that some of the machines are good and others are less appropriate. The question is how to select the best machine considering all the machines suitable for given working conditions. We will give the answer in this paper applying the method, which includes finding the value of proximity between the objects of the given class.

Mining machines quality comparative evaluation

Let us suppose that m mining machines is given and that for each of them n technical characteristics are known. Machines can be presented by a table, matrix A with m×n format, in such way that one row contains all characteristics of a single machine and one column contains every value of a single characteristic. So,

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ . & . & \dots & . \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{bmatrix},$$

where a_{ij} ($i = 1, 2, \dots, m; j = 1, 2, \dots n$) is the value of j-th characteristic for i-th machine. The matrix A will be called the matrix of technical characteristics.

The nature of the technical characteristic is that the biggest or the smallest value of a single characteristic is at the same time the best. This means that it is always possible arrange matrix A (by calculating reciprocal values of some characteristics) in such way that, for example, the biggest value is at the same time the best. For this reason let us find maximum value in every column of matrix A, i.e.:

$$b_j = \max \{a_{1j}, a_{2j}, \dots, a_{mj}\} \; (j = 1, 2, \dots, m),$$

and then let's find the ratio (quotient)

$$q_{ij} = \frac{b_j}{a_{ij}} \; (j = 1, 2, \dots, n; i = 1, 2, \dots, m)$$

and form the matrix

$$Q = \begin{bmatrix} q_{11} & q_{12} & \dots & q_{1n} \\ q_{21} & q_{22} & \dots & q_{2n} \\ . & . & \dots & . \\ q_{m1} & q_{m2} & \dots & q_{mn} \end{bmatrix}.$$

The matrix Q will be called the matrix of technical characteristics (parameters) comparative values. It is obvious that $q_{ij} \geq 1$ for each $i = 1, 2, \dots, m; j = 1, 2, \dots, n$, and that in every column of matrix Q number 1 appears at least once in the place of the highest value of the corresponding parameter in the matrix *A*.

Let us assume that among the machines with technical characteristics presented the matrix A there are k machines ($0 < k < m$) which surely can be considered as the best for given working conditions. Such a conclusion can be drawn from the long-term application of these machines in the equal working conditions or by applying some of the methods for quality evaluation of the mining machines. For simplification, let us assume that those machines are presented by the first k rows of the matrix A and matrix Q.

Value of proximity among those *k* machines we find by using the formulae:

$$(*) \qquad d = \sqrt{\frac{1}{k} \cdot \frac{1}{k-1} \cdot \sum_{i=1}^{k} \sum_{p=1}^{k} \sum_{j=1}^{n} \omega_j \cdot (q_{ij} - q_{pj})^2},$$

where ω_j (j = 1, 2, ... , n) is the weight (influence) of the j-th technical characteristic of a quality of the machine. Value of ω_j is determined based on the years of experience in selection of mining equipment for given working conditions.

To find comparative evaluation of quality for remaining machines presented in matrix A, we shall calculate the value of proximity between all k+1 machines by adding a single machine to the group of k machines taken for comparison. If calculated values of proximity we mark by d_i (i = k+1, k+2, ... ,m), we can calculate $s_i = d_i - d$ called general parameter of machine quality. Conclusion on machine quality is drawn from the following criteria: the smaller s_i = di – d, the better machine.

Example

We will consider 11 loaders with bucket volume ranging from 1,0 to 1,5 m^3. Technical characteristics of the loaders are given in the table 1 (matrix A). Concerning the first, second, third and sixth characteristic the smallest value is the best while for the fourth and fifth the biggest value is the best. This was taken in consideration during the calculation of comparative values of machines technical characteristics. In the first, second, third and sixth column of the matrix A all the values of the single column were divided by the smallest value in that column, while the biggest values in the fourth and fifth column were divided by corresponding values. Comparative values of machines technical characteristics are given in table 2 (matrix Q).

Table 1 (Matrix A)

Loader	Technical characteristic					
	Bucket volum m^3	Mass of machin t	Engine power kW	Max. speed km/h	Payload kg	Min. radius m
VOLVO L30	1,00	5,70	55	20,00	3600	2,68
SCHOPF L82	1,20	6,00	55	18,00	3100	2,80
MAN GHH G-ST-1 ½	1,15	6,30	55	19,80	2040	2,41
MINDEV 1000/19	1,00	9,26	45	2,30	5000	4,30
SALZGITTER EL480	1,00	9,20	45	2,88	3500	4,50
ATLAS COPCO CAVO D710	1,00	15,00	90	19,80	2500	4,35
EIMCO 115B	1,15	21,30	90	9,60	4000	2,11
EMG LBS-1200	1,20	7,86	55	4,00	4200	1,43
ROSSI 850HDA	1,15	7,20	75	15,00	2200	3,50
WAGNER ST-2D	1,50	24,00	55	15,60	3630	2,67
TORO 200D	1,50	11,50	75	21,00	4000	3,20

Table 2 (Matrix Q)

1,0000	1,0000	1,2222	1,0500	1,3889	1,8741
1,2000	1,0526	1,2222	1,1667	1,6129	1,9580
1,1500	1,1053	1,2222	1,0606	2,4510	1,6853
1,0000	1,6246	1,0000	9,1304	1,0000	3,0070
1,0000	1,6140	1,0000	7,2917	1,4286	3,1469
1,0000	2,6316	2,0000	1,0606	2,0000	3,0420
1,1500	3,7368	2,0000	2,1875	1,2500	1,4755
1,2000	1,3789	1,2222	5,2500	1,1905	1,0000
1,1500	1,2632	1,6667	1,4000	2,2727	2,4476
1,5000	4,2105	1,2222	1,1290	1,3774	1,8671
1,5000	2,0175	1,6667	1,0000	1,2500	2,2378

First three given machines were taken for the comparison: VOLVO L30, SCHOPF L82 and MAN GHH G-ST-1 ½. Value of proximity ***d*** among these three machines was calculated according to formulae (*) for k = 3 and n = 6, following that, values of proximity were calculated for all the groups (classes) of four machines which were formed by adding to the first three a single machine from the group of the remaining machines (fourth, fifth, sixth, seventh, eighth, ninth, tenth and eleventh). Value of proximity is also calculated with formulae (*) for k = 4 and n = 6, and they are marked with d_i (i = 4, 5, 6, 7, 8, 9, 10, 11). Values of proximity were calculated for $\omega_j = \frac{1}{6}$ (j = 1, 2, 3, 4, 5, 6) and $\omega_1 = 0{,}20$; $\omega_2 = \omega_3 = \omega_5 = 0{,}15$; $\omega_4 = 0{,}25$; $\omega_6 = 0{,}10$. Achieved results are presented in tables 3 and 4.

Table 3

$\omega_j = \frac{1}{6}$ (j = 1, 2, 3, 4, 5, 6)		
d = 0,3419		
i	d_i	$s_i = d_i - d$
4	2,3799	2,0380
5	1,8620	1,5201
6	0,6768	0,3368
7	0,9309	0,5890
8	1,2725	0,9306
9	0,3926	0,0507
10	0,9683	0,6263
11	0,4744	0,1325

Machines ranking by quality are:

1. ROSSI 850HDA,
2. TORO 200D,
3. ATLAS COPCO CAVO D710,
4. EIMCO 115B,
5. WAGNER ST-2D,

6. EMG LBS-1200,
7. SALZGITTER EL480,
8. MINDEV 1000/19.

Table 4

ω_1=0,20; ω_2=ω_3=ω_5=0,15; ω_4=0,25 and ω_6=0,10		
d = 0,3243		
i	d_i	$s_i = d_i - d$
4	2,8800	2,5557
5	2,2360	1,9116
6	0,6155	0,2911
7	0,9147	0,5904
8	1,5180	1,1936
9	0,3664	0,0421
10	0,9206	0,5963
11	0,4501	0,1258

Machines ranking by quality are:
1. ROSSI 850HDA,
2. TORO 200D,
3. ATLAS COPCO CAVO D710,
4. EIMCO 115B,
5. WAGNER ST-2D,
6. SALZGITTER EL480,
7. EMG LBS-1200,
8. MINDEV 1000/19.

As it can be seen, machines ranking by quality, compared to the three machines chosen for comparison, are almost equal.

Conclusion

Results obtained by applying presented method can be considered as very good. We are of the opinion that taking into consideration only technical characteristics of the machines these results can be useful during the selection of the mining machines as well as during their designing.

REFERENCES

1. Cokorilo V., Milicic M., 1991., Quality comparison of mining equipment based on their technical characteristics, The International Journal of Mining Science and Technology, Vol. 13, 5, p. 291 - 295

2. Milicic M., Cokorilo V., Patrucco M., 1997., Un metodo di valutazione della qualita per macchine da miniera, Quary and Construction No. 9, Septembre 1997, 5, p. 65-69

Recenzent: Prof.dr hab.inż. Walery Szuścik

Omówienie

W artykule przedstawiono metodę matematyczną oceny maszyn i urządzeń. Metoda ta pozwala na wybór najodpowiedniejszej maszyny lub urządzenia uwzględniając arbitalnie dobrane parametry techniczno-eksploatacyjne oferowanych na rynku maszyn górniczych. Omawiana metoda wykorzystuje metodę wag, która jest zastosowana do macierzy parametrów analizowanych maszyn.