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RESEARCH ON THE CONVEYING CAPACITY OF TRANSPORTATION SYSTEMS OF COAL MINES

ANALIZA KAPACITETA TRANSPORTNIH SISTEMA U RUDNICIMA UGLJA

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Abstract: *Findings of investigations on the capacity of conveying systems used to transport the run-of-mine in underground workings of Polish coal mines are presented in the paper. The described investigations have covered the conveyor systems in main transportation roads, were carried out within different periods of operations and had several months duration. The investigations took place in three modern highly productive underground coal mines. The obtain results stating the actual capacity of conveying systems are compared with theoretical capacities of these systems. This will provide the basis on which the utilization factor of the capacity of the conveying systems can be estimated.*

Key words: *belt coveying systems, capacity*

Apstrakt: *U ovom radu prikazani su rezultati istraživanja kapaciteta sistema za transport rovne rude sa podzemnih radilišta u poljskim rudnicima uglja. Pomenuta istraživanja obuhvatila su transportne sisteme na glavnim transportnim pravcima, a sprovedena su u različitim vremenskim periodima u trajanju od nekoliko meseci. Istraživanja su se odvijala u tri moderna, visoko produktivna rudnika uglja sa podzemnom eksploatacijom.*
Dobijeni rezultati, koji pokazuju realni kapacitet transportnih sistema upoređeni su sa teoretskim kapacitetima. Na osnovu toga moguće je proračunati faktor iskorišćenja kapaciteta transportnog sistema

ključne reči: *sistem tračnih transportera, kapacitet*

1 INTRODUCTION

Concentration of extraction is one of the most essential features characterizing the Polish coal mining. As a result of the concentration the demanded output of hard coal comes from longwall faces the number of which is being decreased. Reducing of a length of belt conveyors being installed in the main conveyor roads takes place at the same time. In 1990. the total length of belt conveyors in underground mines was about 830 km and in 2001. it was reduced to 300 km.

1 UVOD

Koncentracija radilišta je jedna od osnovnih karakteristika eksploatacije uglja u Poljskoj. Kao posledica ovoga, potrebna proizvodnja kamenog uglja ostvaruje se na širokim čelima, čiji broj se sve više smanjuje. Istovremeno se smanjuju i dužine trakastih transportera koji se postavljaju na glavne transportne pravce. U 1990. godini ukupna dužina tračnih transportera u podzemnim rudnicima iznosila je oko 830 km, dok je 2001. godine smanjena na 300 km.

With a decreasing number of highly productive faces the transportation systems have to convey streams of run-of-mine coal at a correspondingly higher rate of flow. This being so, there is a need for modern coal haulage systems to provide the correspondingly higher conveying capacity – being characterized by higher performance.

When designing new haulage systems for the main conveyor roads applicable for many yearsž operation the assumption is made that in a given working panel or at a given working level of the seam there is a possibility to realize longwall faces of defined parametres and equipped with supposed machinery being determinant of the volume of run-of-mine stream taken over by the haulage system. On account of new generations of machines which can find application on longwall faces put into operation later on, it is assumed that the operation on faces from which the run-of-mine coal is supplied to the haulage system can be non-uniform and that there are some reserve conveying capacities of the system. In general, new generations of winning machines provide higher extraction capacities.

In consideration of the above named factors the assumed planned conveying capacity of a coal haulage system is usually greater than that really needed. That is the case not only at the moment of starting the system but applies to its operation in the future. It is obvious that higher conveying capacity of the system results from the selection and installation of conveyors incorporating belts characterized by higher technical and operational parameters. This involves higher capital costs and operating ones. Thus, determining of the real level of reserve capacity of the haulage system as related to the existing needs seems to be of essential importance. Findings of the investigations, the objective of which has been to analyse the state of the art in four coal mines selected at random, are described and analysed in this paper.

2 METHODOLOGY OF INVESTIGATIONS ON THE REAL CONVEYING CAPACITY OF COAL HAULAGE SYSTEMS IN HARD COAL MINES AND THE OBTAINED RESULTS

Investigations of the real conveying capacity of coal haulage systems in main conveying roads have been carried out in four hard coal mines. They covered seven various coal haulage systems.

In opinion of the mine technical staff all coal haulage systems achieved their target perfomance corresponding to the production capacity of a

Sa smanjenim brojem visoko produktivnih otkopnih frontova transportni sistemi moraju da otpremaju rovni ugalj većom brzinom. S obzirom na novonastalu situaciju potrebno je uvesti modernije sisteme za transport uglja, kako bi se obezbedio odgovarajući transportni kapacitet i bolji učinak.

Prilikom projektovanja novih transportnih sistema za glavne transportne pravce koji treba da budu u funkciji dugi niz godina, pretpostavlja, se da u datom otkopnom pojasu ili na datom otkopnom horizontu u sloju, postoji mogućnost otvaranja širokih čela određenih parametara. Oni treba da su opremljeni pretpostavljenom opremom koja određuje kcličinu rovne rude koju preuzima transportni sistem. Zahvaljujući novoj generaciji mašina koje se mogu primeniti u radu na širokom čelu, pretpostavlja se da se radovi na otkopnom frontu ne moraju odvijati ujednačeno i da sistem raspolaže rezervnim transportnim kapacitetima. Osim toga, nove generacije eksploatacionih mašina generalno imaju daleko veći kapacitet.

Uzimajući u obzir prethodno navedene faktore, pretpostavljen planirani kapacitet sistema za transport uglja je u većini slučajeva veći nego što je to realno potrebno. To nije slučaj samo u periodu kada se sistem pušta u rad, već se odnosi na budući rad sistema. Očigledno je da veći transportni kapacitet sistema proizilazi iz izbora i ugradnje transportnih traka koje imaju daleko bolje tehničke i operativne parametre. Ovo podrazumeva veće investicione i operativne troškove. Prema tome, određivanje realnog nivoa rezervnog kapaciteta transportnog sistema u odnosu na postojeće potrebe je od izuzetnog značaja. U ovom radu analizirani su rezultati istraživanja, čiji je cilj bio da razmotri savremena tehnološka dostignuća, trenutno u eksploataciji u nekim rudnicima uglja koji su odabrani metodom slučajnog izbora.

2 METODOLOGIJA ISTRAŽIVANJA REALNOG KAPACITETA TRANSPORTNIH SISTEMA U RUDNICIMA KAMENOG UGLJA I DOBIJENI REZULTATI

Istraživanja realnog kapaciteta transportnog sistema na glavnim transportnim pravcima sprovedena su u naša četiri rudnika kamenog uglja. Ova istraživanja obuhvataju sedam različitih transportnih sistema.

Po mišljenju tehničkog osoblja, koje je zaposleno u rudniku, svi sistemi za transport uglja su postigli

working panel or a working level from which run-of-mine coal was transported away.

A method used to investigate the real conveying capacity of haulage systems was conditioned by the possibility of acquiring and recording of the data necessary to carry out the calculations. Data illustrating the coal haulage systems under investigation are presented in Table 1. The lowest capacity of a conveyor being incorporated and operated in the system has been recognized as the conveying capacity of the system being investigated and is presented in the table. However, it is to point out that differences in the nominal conveying capacity of particular conveyors of which the tested haulage system was composed were very small.

The real conveying capacity of coal haulage systems was tested at different time within the compass of three years. The duration of investigations carrried out on particular systems was also different. It ranged between eight months in case of the coal haulage systems installed in the mine A and one month in case of the mines C and D. Example of haulage system is shown on figure 1

ciljni kapacitet koji odgovara proizvodnom kapacitetu u otkopnom pojasu ili u otkopnom horizontu iz kojih se izvozi rovni ugalj.

Metoda koja je primenjena za istraživanje kapaciteta transportnog sistema zavisi od mogućnosti obezbeđivanja i prikupljanja podataka neophodnih za obračun. U tabeli 1 prikazani su podaci kojima se ilustruju razmatrani sistemi za transport uglja. Najmanji kapacitet jednog transportera koji radi u okviru sistema uzima se kao transportni kapacitet analiziranog sistema i kao takav predstavljen u tabeli. Međutim, treba napomenuti da su razlike u nominalnim kapacitetima pojedinih transportera koji čine sistem veoma male.

Realni kapacitet sistema za transport uglja ispitivan je u različitim vremenskim intervalima u periodu od tri godine. Pojedini sistemi istraživani su u različitim vremenskim periodima, koji su se kretali od osam meseci u slučaju sistema za transport uglja instaliranih u rudniku A do mesec dana za rudnike C i D. Primer transportnog sistema prikazan je na slici 1.

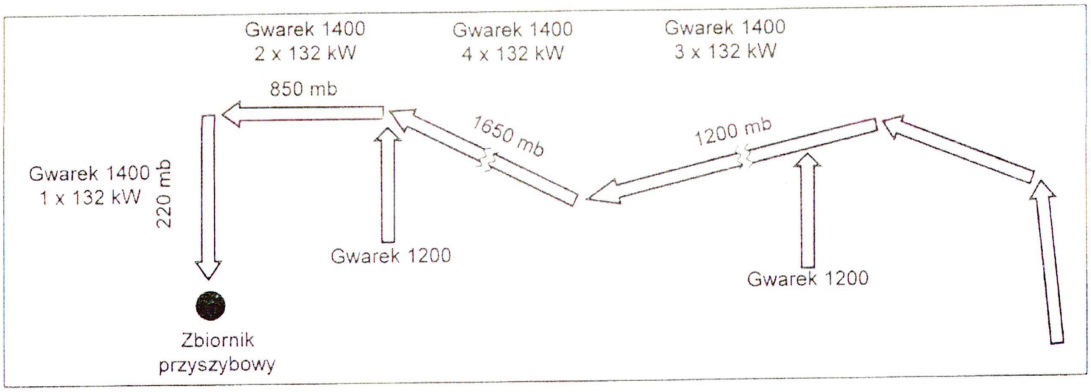

Figure 1 Example of haulage system
slika 1 Primer transportnog sistema

The investigations were performed at different time so that reliability of the collected information be ensured. Whenever the information about the conveying capacity of the system was gathered from entries in report books, in which worktimes of the system during twenty-four hours and data relating to the output of particular faces supplying run-of-mine to the haulage system were written down, the duration of the investigations was longer. On the basis of these data average real conveying capacities of the system for a monthž s period were calculated. The calculated results are presented in Table 2. The last row of the table contains average results obtained within the whole

Istraživanja su sprovedena u različitim vremenskim periodima kako bi se obezbedila pouzdanost prikupljenih podataka. Period istraživanja bio je duži u slučajevima kada su se informacije o transportnom kapacitetu prikupljale iz pisanih izveštaja u kojima je vođena evidencija radnih sati u toku dvadeset četiri časa i evidencija o proizvodnom kapacitetu na pojedinim otkopima sa kojih je rovni ugalj otpreman na transportni sistem. Na osnovu ovih podataka vršeni su obračuni prosečnih realnih transportnih kapaciteta sistema za period od mesec dana. Rezultati ovih obračuna prikazani su u tabeli 2. U poslednjem redu tabele date su prosečne vrednosti za čitav

space of investigations as determined from monthly average real capacities of the haulage systems stated for particular months.

In case of the haulage systems in which the operation of conveyor drives was recorded and, thus, the reliability of acquired data was higher, the duration of investigations was shorter. The operation of drives was recorded in two haulage systems (Table 1) in which the drives had been equipped with frequency converters allowing the speed of a conveyor belt to be adjusted to the stream of run-of-mine coal being transported. When carrying out the investigations the assumption was made that the recorded speed of a belt corresponded to the real conveying capacity of the system. This was determined on the basis of the speed being recorded. Example of oscillogram of conveying capacity is shown on figure 2.

period istraživanja koje su utvrđene na osnovu pojedinačnih prosečnih mesečnih kapaciteta transportnog sistema.

U slučajevima kada se kapacitet sistema analizirao na bazi rada pogonskih stanica transportera pouzdanost prikupljenih podataka je bila daleko veća a istraživanja su kraće trajala. Rad pogonskih stanica posmatran je i evidentiran na dva transportna sistema (tabela 1), na kojima su pogonske stanice opremljene konvertorima frekvence koji omogućavaju regulaciju brzine transportne trake, odnosno njeno usklađivanje za protokom rovnog uglja. U toku istraživanja usvojena je pretpostavka da evidentirana brzina trake odgovara realnom transportnom kapacitetu sistema. Ovo je ustanovljeno na osnovu evidentirane brzine. Oscilogram transportnih kapaciteta dat je na slici 2.

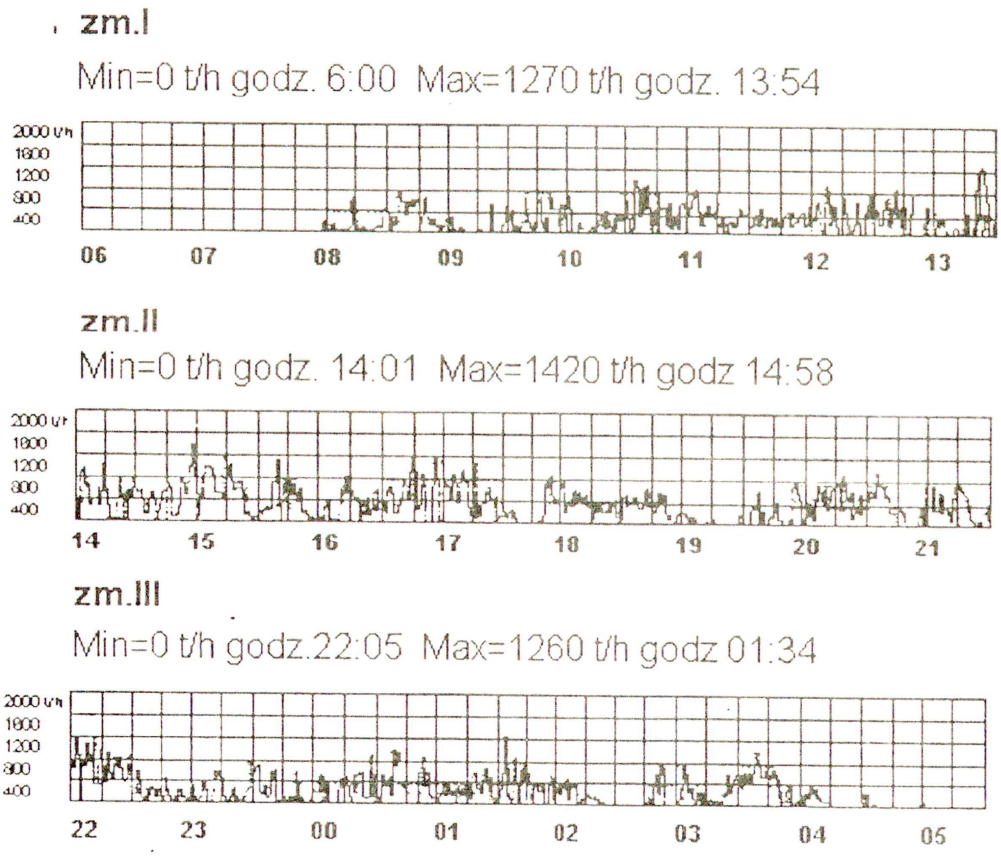

Figure 2 Exemplary oscillogram of conveying capacity
slika 2 Primer oscilograma transportnog kapaciteta

Table 3 contains results of records presented as percentage portions of worktime of the conveyor running at a belt speed within a given speed range. Average values of the real conveying capacity of haulage systems calculated for a whole month of observations are presented in the last row of the table.

U tabeli 3 rezultati ispitivanja prikazani su u procentima radnih sati transportera čija se traka kreće brzinom koja oscilira u okviru unapred određenih vrednosti. Prosečne vrednosti realnog transportnog kapaciteta sistema obračunate na osnovu rezultata mesečnih istraživanja prikazane su u poslednjem redu tabele.

It is to point out that the highest recorded values of real conveying capacities of the haulage systems under investigation amounted to 1520 t/h in case of the haulage system of the mine C and 1420 t/h in case of the haulage system of the mine D. These capacities occurred only once within a very short time interval of several score seconds.

Treba istaći da maksimalna zabeležena vrednost realnog kapaciteta transportnog sistema u radu u rudniku C iznosi 1520 t/h, a u rudniku D 1420 t/h. Ovi kapaciteti zabeleženi su samo u jednoj prilici u kratkom vremenskom intervalu od svega nekoliko sekundi.

Table 1 Specification of data relating to coal haulage systems under investigation
tabela 1 Specifikacija podataka koji se odnose na posmatrani sistem za transport uglja

Coal mine	Haulage system No	Haulage	Conveying capacity, t/h	Duration of investigation in months	Method of data acquisition
A	1	from a panel	1383	8	extracts from report books
	2	from a panel	747	8	extracts from report books
	3	from a panel	1427	8	extracts from report books
B	1	from a level	1450	6	extracts from report books
	2	from a panel	1150	6	extracts from report books
C	1	from a level	1800	1	Recording
D	1	from a level	1800	1	Recording

Table 2 Results of investigations of the real conveying capacity of coal haulage systems of the coal mines A, B, t/h
tabela 2 Rezultati istraživanja realnog kapaciteta sistema za transport u rudnicima uglja A, B, t/h

Item	Coal mine A - coal haulage system			Coal mine B - coal haulage system	
	1	2	3	1	2
1	375	140	329	195	208
2	303	196	291	198	224
3	318	135	358	208	236
4	442	106	375	212	228
5	486	174	307	225	240
6	642	199	314	228	219
7	572	219	378	-	-
8	621	169	302	-	-
r	470	167	332	211	225

Table 3 Results of investigations of the real conveying capacity of coal haulage systems of the coal mines C and D
tabela 3 Rezultati istraživanja realnog kapaciteta sistema za transport u rudnicima uglja C i D

Coal mine C			Coal mine D		
Speed range	Worktime within the speed range, %	Average capacity,t/h	Speed range	Worktime within the speed range, %	Average capacity, t/h
$< 0,4\ v_n$	53,3	360	$< 0,4\ v_n$	89,7	360
$0,4 - 0,6\ v_n$	38,3	900	$0,4 - 0,6\ v_n$	9,6	900
$0,6 - 0,8\ v_n$	7,1	1260	$0,6 - 0,8\ v_n$	0,7	1260
$0,8 - 1,0\ v_n$	1,3	1620	$0,8 - 1,0\ v_n$	-	1620
Average conveying capacity		647	Average conveying capacity		418

The determined values of real conveying capacities of the haulage systems being investigated have been related to nominal values illustrating the transportation potential of the systems and the obtained results have been analysed.

U nastavku su analizirane ustanovljene vrednosti realnog kapaciteta posmatranih transportnih sistema, koji se odnose na nominalne vrednosti, a ilustruju njihov transportni potencijal, a analizirani su i dobijeni rezultati.

3 ANALYSIS OF RESULTS OF THE INVESTIGATIONS

A number of results obtained from the investigations of real conveying capacities of the coal haulage systems operated in hard coal mines are presented in tables of the paragraph 2. In consideration of the defined parameters of conveyors of which the haulage systems are composed, each system provides a definite potential for conveying the run-of-mine coal. This is its conveying capacity. Table 2 presents that conveying capacity of particular systems.

With the real conveying capacities and the transportation potential of the system being taken as the basis utilization factors of the transportation potential of the system W have been determined to be used in the carried out analysis. The utilization factor is a quotient of the two afore-named quantities. In a formula it takes a form :

$$W_w = W_{rz} / W_n \qquad (1)$$

where :
W_{rz} - real conveying capacity of a coal haulage system
W_n - transportation potential of a coal haulage system

The calculated utilization factors of the transportation potential of the coal haulage systems are contained in Table 4. In case of the coal mines A and B the named factors have been related to particular months and their average values for the whole period of investigations are presented. For the coal mines C and D the values are given which refer to the whole one month s period of investigations.

3 ANALIZA REZULTATA ISTRAŽIVANJA

Neki od rezultata istraživanja realnog kapaciteta transportnih sistema u rudnicima kamenog uglja prikazani su u tabelama datim u Poglavlju 2. U odnosu na parametre svakog pojedinačnog transportera koji čine sisteme transporta, svaki sistem raspolaže odgovarajućim potencijalom transporta rovnog uglja. Ta vrednost ustvari predstavlja njegov transportni kapacitet. U tabeli 2 prikazani su pomenuti transportni kapaciteti za svaki pojedinačni sistem.

Pomoću realnih transportnih kapaciteta i transportnog potencijala sistema, moguće je odrediti faktor iskorišćenja transportnog potencijala, koji se koristi u daljoj analizi. Faktor iskorišćenja predstavlja količnik dve prethodno navedene vrednosti, što izraženo u formuli glasi:

$$W_w = W_{rz} / W_n, \qquad (1)$$

gde je :
W_{rz} - realni kapacitet sistema za transport uglja i
W_n - potencijal sistema za transport uglja.

Obračunati faktori iskorišćenja potencijala sistema za transport uglja dati su u tabeli 4. U rudnicima uglja A i B pomenuti faktori odnose se na određene mesece, a prikazane su njihove prosečne vrednosti za čitav period istraživanja. Za rudnike uglja C i D date vrednosti odnose se na period od mesec dana istraživanja.

Table 4 Utilization factors of the transportation potential of the coal haulage systems under investigation
tabela 4 Faktor iskorišćenja potencijala analiziranog sistema za transport uglja

	Coal mine A			Coal mine B		Coal mine C	Coal mine D
	1	2	3	1	2		
1	0,27	0,19	0,23	0,17	0,14		
2	0,22	0,26	0,20	0,17	0,15		
3	0,23	0,18	0,25	0,18	0,16		
4	0,32	0,14	0,26	0,18	0,16		
5	0,35	0,23	0,22	0,20	0,17	0,36	0,23
6	0,46	0,27	0,22	0,20	0,15		
7	0,41	0,29	0,26	-	-		
8	0,45	0,23	0,21	-	-		
Average	0. 34	0. 22	0. 33	0. 18	0.16		

From the results specified in Table 4 it appears that utilization of the transportation potential of the coal haulage systems under investigation are considerably differentiated. The utilization factor ranges from 0.16 for the haulage system 2 of the coal mine B to 0.36 for the haulage system of the coal mine C.

Finding out if the obtained factors have common features or if they differentiate one from another would be of interest. Testing of homogeneity of the obtained utilization factors have been performed using a rank test of sums [1]. When carrying out the first series of tests it has been assumed that the obtained monthly factors of the transportation potential for particular coal haulage systems of one coal mine are homogeneous. Thus, three separate objects in the coal mine A and two objects in the coal mine B were examined. Each object being tested in the coal mine A indicated eight realizations of the feature of our concern i. e. of utilization of the transportation potential. In case of the coal mine B six such realizations were recorded in each object under examination.

Testing of homogeneity was performed with the aid of the rank test as follows. One non-decreasing sequence of numbers was formed from the given factors of the coal haulage systems being examined and proper ranks were attributed to these numbers. Then sums of the ranks were calculated for particular sequences of numbers describing each system individually. The sums were designated as $V_{\Sigma i}$. Then a value of statistics was calculated

$$\chi^2_{k-1} = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{V_{\Sigma i}^2}{n_i} - 3(n+1), \qquad (2)$$

where :

$$n = \sum_{i=1}^{k} n_i .$$

If the tested hypothesis H_o stating homogeneity of the data i. e. $F_1(x) = F_2(x) = \ldots\ldots F_k(x)$, where $F_i(x)$ is a feature distrubution function in the i-th object, is true, then the statistics (2) is characterized by an asymptotic distribution X^2 with k – 1 degrees of freedom. The critical value X^2_{a} (k – 1) was taken from tables of the distribution X^2 for the significance level L for k – 1 degrees of freedom as assumed a priori.

If $\chi^2_{k-1} \geq \chi^2_{\alpha}(k-1)$ takes place the hypothesis is rejected. Otherwise, there is not any ground to

Iz rezultata navedenih u tabeli 4 proizilazi da je stepen iskorišćenja transportnog potencijala analiziranog sistema prilično visok. Naime, faktor iskorišćenja kreće se od 0.16 za transportni sistem 2 u rudniku uglja B do 0.36 za transportni sistem u rudniku uglja C.

Zanimljivo bi bilo ustanoviti da li dobijeni faktori imaju zajedničke karakteristike, ili se međusobno razlikuju. Međusobni odnos i sličnost između dobijenih faktora, odnosno njihova ujednačenost određuje se primenom kategorizacije zbirova [1]. Prilikom prve kategorizacije pretpostavljeno je da su dobijeni mesečni faktori isti za svaki pojedinačni sistem transporta. Prema tome, pojedinačno su analizirana tri sistema u rudniku uglja A i dva sistema u rudniku B. U svakom ispitivanom sistemu u rudniku A došlo je osam puta do realizacija tražene karakteristike, tj. do iskorišćenja transportnog potencijala. U rudniku B na svakom posmatranom sistemu pomenuti rezultat evidentiran je šest puta.

Utvrđivanje gore pomenute ujednačenosti dobijenih faktora izvršeno je uz pomoć kategorizacije, na sledeći način. Od dobijenih faktora formiran je jedan neopadajući niz brojeva, a tim brojevima dodeljena je odgovarajuća kategorija. Zbir kategorija izračunat je za pojedinačne nizove brojeva koji definišu svaki sistem ponaosob. Ovi zbirovi su označeni kao $V_{\Sigma i}$. Nakon toga izračunata je statistička vrednost:

$$\chi^2_{k-1} = \frac{12}{n(n+1)} \sum_{i=1}^{k} \frac{V_{\Sigma i}^2}{n_i} - 3(n+1), \qquad (2)$$

gde je:

$$n = \sum_{i=1}^{k} n_i .$$

Ako analizirana hipoteza H_o određuje ujednačenost podataka, tj. $F_1(x) = F_2(x) = \ldots\ldots F_k(x)$, gde je $F_i(x)$ karakteristična distributivna funkcija u i-tom sistemu, tačna, onda je statistička vrednost (2) koju odlikuje asimptotska raspodela X^2 sa k – 1 stepena slobode. Kritična vrednost X^2_{a} (k – 1) uzeta iz tabela koje označavaju raspodelu X^2 za relevantnost L za k – 1 stepena slobode koji se pretpostavljaju a priori.

Ako dođe do $\chi^2_{k-1} \geq \chi^2_{\alpha}(k-1)$ hipoteza se odbacuje. U suprotnom, nema osnova za

reject the hypothesis of the assumption being verified.

odbacivanje hipoteze za pretpostavku koja se dokazuje.

Table 5 presents data which serve as the basis for testing the homogeneity of utilization factors of the transportation potential of coal haulage systems of the coal mine A

Tabela 5 predstavlja podatke koji su osnov za ispitivanje ujednačenosti faktora iskorišćenja potencijala transportnog sistema u rudniku uglja A.

Table 5 Data for testing the homogeneity of utilization factors of the transportation potential of coal haulage systems of the coal mine A

tabela 5 Podaci za ispitivanje ujednačenosti faktora iskorišćenja potencijala transportnog sistema u rudniku uglja A

Item	System 1		System 2		System 3	
	Factor	Rank	Factor	Rank	Factor	Rank
1	0,27	17,5	0,19	3	0,23	10,5
2	0,22	7	0,26	15	0,20	4
3	0,23	10,5	0,18	2	0,25	13
4	0,32	20	0,14	1	0,26	15
5	0,35	21	0,23	10,5	0,22	7
6	0,46	24	0,27	17,5	0,22	7
7	0,41	22	0,29	19	0,26	15
8	0,45	23	0,23	10,5	0,21	5
	Rank sum : 145		Rank sum : 78. 5		Rank sum : 76. 5	

The quantities given in Table 5 made it possible to calculate statistics (2). The total size of the factor realization in three coal haulage systems is n=8+8+8=24 and the statistics value is:

$$\chi^2_{3-1} = \frac{12}{12(12+1)}\left(\frac{145^2}{8}+\frac{78.5^2}{8}+\frac{76.5^2}{8}\right)-3(12+1) = 7,6.$$

Količine date u tabeli 5 omogućavaju statistički proračun (2). Ukupna realizacija pomenutog faktora za tri transportna sistema iznosi n = 8 + 8 + 8 = 24, a statistička vrednost je:

$$\chi^2_{3-1} = \frac{12}{12(12+1)}\left(\frac{145^2}{8}+\frac{78.5^2}{8}+\frac{76.5^2}{8}\right)-3(12+1) = 7,6.$$

A criltical value of statistics was read out from corresponding tables of statistical distribution for the assumed significance level L = 0. 05 and two degrees of freedom. In case of this testing the value amounted to :

$$\chi^2_{\alpha=0,01}(2) = 9,21 \quad \chi^2_2 = 7,6 .$$

Kritična statistička vrednost očitava se iz tabela statističke raspodele za predpostavljenu relevantnost L = 0. 05 i dva stepena slobode. Kod ovog istraživanja vrednost iznosi:

$$\chi^2_{\alpha=0,01}(2) = 9,21 \quad \chi^2_2 = 7,6 .$$

and was greater than the calculated value of statistics (2).

a veća je od obračunate statističke vrednosti (2).

This being so, with the assumed significance level there was not any ground to reject the hypothesis H_o stating that utilization factors of three coal haulage systems in the coal mine A are homogeneous.

S obzirom na to, uz pretpostavljenu relevantnost, ne postoji osnov za odbacivanje hipoteze H_o kojom se tvrdi da su faktori iskorišćenja za tri transportna sistema u rudniku uglja A ujednačeni.

Similarly, data characterizing the coal mine B were analysed. The size of realization of the factor values was n =6+6=12 and the assumed significance level was L=0.05. An analysis of the objective factors of two coal haulage systems brought about the following results :

Slično tome, analizirani su podaci koji karakterišu rudnik uglja B. Stepen realizacije faktora iznosi n = 6 + 6 = 12, dok je pretpostavljena relevantnost L = 0. 05. Analiza objektivnih faktora za dva transportna sistema dovela je do sledećih rezultata:

$$\chi_1^2 = 4 \leq \chi^2_{\alpha=0,05}(1) = 6{,}64 .$$

This being so, similarly as in case of the coal mine A, no ground was found to reject the hypothesis H_o stating that utilization factors of two coal haulage systems are homogeneous.

The next step of the analysis of results consisted in testing of homogeneity of the objective factor in the two coal mines A and B. Both coal mines indicated the size of realization of the factor amounting to n = 36 and the assumed significance level was of L = 0. 05. The obtained result is as follows :

$$\chi_4^2 = 42{,}2 \geq \chi^2_{\alpha=0,05}(4) = 11{,}34 .$$

The result means that it is necessary to reject the hypothesis H_o stating that utilization factors of the transportation potential of five coal haulage systems in the two coal mines are homogeneous.

4 RECAPITULATION

From an analysis of the real conveying capacity, with which coal haulage systems in the main conveyor roads are operated, in four coal mines it has become evident that the utilization factor of the transportation potential is relatively low. When related to avarage values from the whole periods of investigations it ranged between 0.16 in case of the coal haulage system in the coal mine B and 0.36 for the coal haulage system in the coal mine C. Average utilization factors considered in the space of one month indicated ranging between 0.14 in case of coal haulage systems of the coal mine B and 0.46 for the coal haulage system 1 in the coal mine A. For instantaneous conveying capacities as recorded within time intervals of several score seconds the maximum utilization factor was of 0.84 in the coal mine C.

From a statistical analysis of utilization factors of the transportation potential it has appeared that in particular coal mines they are homogeneous. No homogeneity has been found in case of factors when compared as obtained in two coal mines. A way in which a use is made of the coal haulage systems and the approach to designing these systems and to predicting the output to be taken over by the haulage systems may affect this feature.

The performed analysis has revealed that in all cases the coal haulage systems show considerable reserves of the transportation potential. This is a

$$\chi_1^2 = 4 \leq \chi^2_{\alpha=0,05}(1) = 6{,}64 .$$

A s obzirom na to, slično kao i u slučaju rudnika uglja A, ne postoji osnov za odbacivanje hipoteze H_o kojom se tvrdi da su faktori iskorišćenja za dva transportna sistema ujednačeni.

Sledeći korak u analizi rezultata sastoji se od ispitivanja ujednačenosti objektivnog faktora za dva rudnika uglja A i B. Za oba rudnika naznačen je stepen realizacije faktora koji iznosi n = 36, a pretpostavljena relevantnost je L = 0. 05. Dobijeni su sledeći rezultati:

$$\chi_4^2 = 42{,}2 \geq \chi^2_{\alpha=0,05}(4) = 11{,}34 .$$

Iz ovog rezultata može se zaključiti da je neophodno odbaciti hipotezu H_o kojom se tvrdi da su faktor iskorišćenja potencijala pet sistema za transport uglja u dva rudnika uglja ujednačeni.

4 REKAPITULACIJA

Analizom realnog transportnog kapaciteta sa kojim rade sistemi za transport uglja na glavnim transportnim pravcima, u četiri rudnika uglja dolazi se do zaključka da je faktor iskorišćenja transportnog potencijala relativno nizak. U odnosu na prosečne vrednosti za čitav period ispitivanja pomenuta vrednost kreće se od 0.16 u slučaju transportnog sistema u ridniku uglja B do 0.36 u slučaju transportnog sistema u rudniku uglja C. Prosečni faktori iskorišćenja za period od mesec dana osciliraju od 0.14 u slučaju transportnih sistema u rudniku uglja B, do 0.46 u slučaju transportnog sistema 1 u rudniku uglja A. Za trenutni transportni kapacitet koji je zabeležen u kratkom vremenskom intervalu od svega nekoliko sekundi, maksimalni faktor iskorišćenja je iznosio 0.84 i to u rudniku uglja C.

Na osnovu statističke analize faktora iskorišćenja transportnog potencijala može se zaključiti da su oni ujednačeni, odnosno uniformni u pojedinim rudnicima uglja. U slučaju dva rudnika uglja prilikom poređenja faktora nije konstatovana ujednačenost. Na pomenutu karakteristiku može uticati način korišćenja transportnog sistema, kao i sam projekat i predviđeni proizvodni kapacitet koji transportni sistem treba da prihvati.

Prikazana analiza pokazala je da kod svih transportnih sistema postoji značajna rezerva u transportnom potencijalu, što predstavlja tipičan pristup u projektovanju transportnih sistema. Na

typical feature of designing the transportation systems. Results contained in [2] of German publications are indicative of this.

The application of frequency converters seems to be an advantageous solution contributing to mitigation of the problem of operating costs. Frequency converters allow the speed of a belt to be limited whenever loading of the conveyor belt with material conveyed is too low as well as they enable an increase of short duration in speed of the belt in moments of overloading the belt.

The problem of utilization of the transportation potential of coal haulage systems being dealt with in this paper seems to be interesting and is worthy of notice and further investigation.

ovo jasno ukazuju rezultati izneti u nemačkom izdanju [2].

Primena konvertora frekvencije pokazala se kao veoma povoljno rešenja koje ima značajan doprinos u smanjenju operativnih troškova. Konvertori frekvence omogućavaju podešavanje brzine trake transportera prilikom utovara materijala u skladu sa trenutnim opterećenjem.

Pitanje iskorišćenja potencijala sistema za transport uglja, koji je delimično razrađen u ovom radu, je veoma interesantno i vredno pomena, pa ga je potrebno dalje istražiti.

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