Determination of reliability parameters of locomotive transport system in main haulage drift in the Toranica lead and zinc mine

Zoran Despodov [1]

Stanovenie parametrov spoľahlivosti systému lokomotívnej dopravy na hlavnej ťažobnej chodbe Pb-Zn bane Toranica

Práca podáva výpočeť parametrov spoľahlivosti lokomotívneho transportného systému (MHD) v hlavnej ťažobnej chodbe Pb-Zn ložiska Toranica. Údaje boli získané priamym meraním počas prevádzky. Analýza prestojov a času kontinuálnej prevádzky MHD bola uskutočnená počas desiatich smien.

Key words: Toranica, lead and zinc, main haulage drift, parameters of reliability, standstiils.

Introduction

The reliability of locomotive transport system in MHD in the Toranica mine is of importance for the total effect and accomplishment of production plans. The paper presents reliability parameters determined for the first time as well as legality of related standstills of locomotive transport system.

Description of locomotive transport system in MHD

MHD represents the mainway through which the total amount of run-of-mine ore in the Toranica underground mine is hoisted to the surface and to the mineral processing facility. Its adit is at peak 1250.45 m and total length to the loading station amounts to 2574 m. The drift profile is horse-shoe in shape, with clear profile plane of up to $P_{cp} = 9\ m^2$. The average drift dip is 4%o provided with a 750 mm wide rail, the rail mass being 35 kg/m. Two AC/DC inverters each of 160 kVA are fitted, the trolley line being supplied with electric voltage of 250 V. The drift is designed for the capacity of 700 000 t/y as is the designed annual production of the mine.

The locomotive transport for run-of-mine ore uses transportation means as follows:

- electric locomotive (K-14, Russian type),
- granby type mining cars (the volume 3.5 m^3, MZT Skopje).

Tab.1. Main technical data of locomotive.

mass	(tons)	14
motor rating per one-hour regime	(kW)	90
tractive effort, one-hour	(N)	23500
one-hour speed	(km/h)	12.8
nominal voltage	(V)	250
gauge	(mm)	750
distance between axles	(mm)	1800
length	(mm)	5600
width	(mm)	1300
height	(mm)	1650
wheel diameter	(mm)	760

At present haulage of run-of-mine ore is performed by ten cars in three shifts that carry out 15 haulages a day or the capacity of 300 000 tons per year.

[1] *Zoran Despodov, MSc.* Faculty of Mining and Geology - Stip, Republic of Macedonia
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Calculation of reliability parameters of locomotive transport system in main haulage drift

In addition to its advantages the relationship of elements in transportation system has some disadvantages. Disadvantages are that fall out of each element of the system results in standstill of the whole haulage system. This, in tern, results in significant economic losses and particular attention should be paid to the providing of continual work of the haulage system.

Reliability of haulage system is defined as capability to perform a given function in certain period of time. It is important to mention that here they are renewable systems or systems that are sent to repairs after each breakdown and put in production after maintenance.

Standstill is defined as an event after which the system outpasses allowed limits that cause standstill of normal operation. Breakdowns result in standstills which are state in the system between the moment of end of normal work and the beginning of the next period of continual work.

Reliability of haulage system can generally be represented as plausibility work without standstills in time t determined by possible incident $tp>t$, where t represents time interval between consecutive break or

$$Po(t) = P(tp \geq t) \quad (1)$$

Several characteristics illustrate the reliability of haulage system such as break course parameter, parameter of course of resumptions, readiness coefficient, time utilization coefficient, machine time coefficient, time utilization coefficient for calculation, standstill course parameter, etc.

Listed below are patterns applied in calculation of more significant reliability parameters of haulage system (Grujic,1992):

- Time utilization coefficient

$$K_b = \frac{\sum_1^n t_{hi} + \sum_1^k t_{zsj}}{t} \quad (2)$$

where:

t_{hi} – is the time period of i period of continual performance of locomotive transport system (min);

t_{zsj} – - the time of j standstill caused by technological units directly connected with locomotive transport system (min.);

t - the time for observing of locomotive transport system (min);

- Machine time coefficient:

$$K_m = \frac{\sum_1^n t_{hi}}{t} \quad (3)$$

- Time utilization coefficient for calculation:

$$K_{br} = \frac{K_m}{1 - K_b + K_m} \quad (4)$$

Values of these parameters for various number of shifts are shown in Table 1.

Tab.2. Parameters of reliability of the transport system in MHD.

Number of shifts	K_b	K_m	K_{br}
1	0.95	0.78	0.94
3	0.95	0.71	0.93
10	0.89	0.65	0.85

Values obtained illustrate that an increase of time for observing locomotive transport system results in decrease of values of reliability parameters owing to the increase of standstills.

Calendar time for observing, the effective time of work and duration of planned and standstills unplanned of locomotive transport system of MHD are shown in Table 2.

Tab.3. Standstill of locomotive transport system in MHD.

	minutes(hours)	%
Calendar time for observation	3900 (65.0)	100.0
Effective time of operation of the system	2537 (42.3)	65.0
Duration of standstills planned	489 (8.1)	12.6
Duration of standstiills unplanned	874 (14.6)	22.4

Planned standstills include standstills of the system during survey of locomotive and mine cars, the time for lunch and rest of workers, time elapsed at switch points, machine servicing with machine oil, loading of explosive, etc.

Unplanned or accidental standstills and number of breaks of locomotive transport system of MHD are given in Table 3.

Tab.4. Unplanned standstills.

type of standstills	duration of standstills (min.)	percent of standstills (%)	number of standstills
standstills on loading point	220.3	25.2	8
defect on pantograph	77.6	8.9	1
disconnection and connection of mine cars	10.7	1.2	3
break of current	65.3	7.5	3
standstills on unloading point	54.1	6.2	5
slip out of cars	99.5	11.4	3
small defect on mine cars	10.7	1.2	1
full receiving ore bin	40.1	4.6	1
obstacles on the gauge	3.0	0.3	1
no ore at loading point	210.3	24.1	2
locomotive break	60.0	6.9	1
fall out of pantograph	22.7	2.6	5
TOTAL	874.3	100.0	34

Table 3 shows that most of the standstills take place at the loading point due to blockade of ore pass, water presence, etc.

Standstills course parameter is:

$$\bar{\lambda} = \frac{1}{\bar{t}_h} = \frac{1}{61.2} = 0.0163 \approx 0.02 \qquad (5)$$

$$\bar{t}_h = \frac{\sum_{i=1}^{n} t_{hi} + \sum_{j=1}^{k} t_{hzj}}{n+k} = \frac{2537 + 524.8}{34 + 16} = 61.2 \min \qquad (6)$$

$\bar{t}_h$ - represents medium duration of periods of continual operation of locomotive transport system MHD, (min);

$\sum_{i=1}^{n} t_{hi} = 2537 \min$ is effective time of operation of the system, (see Table 3);

$\sum_{j=1}^{k} t_{hzj}$ – duration of j- period of conditionally continual operation coordinated with duration of j - standstill due to adjacent technological units connected with the locomotive transport system on MHD, (min), (see Table 4);

k - is standstill number caused by other technological units connected with the MHD transport system, (see Table 4) ;

n - number of break in the system for the period observed, (see Table 4) ;

Standstills are of unplanned character and are defined by the density of distribution. The density of standstill distribution can be predicted by the function (Ponomarenko, 1975):

$$f(t) = \lambda \cdot e^{-\lambda t} \quad (7)$$

in case of standstill of locomotive transport system in MHD:

$$f(t) = 0.02 \cdot e^{-0.02t} \quad (8)$$

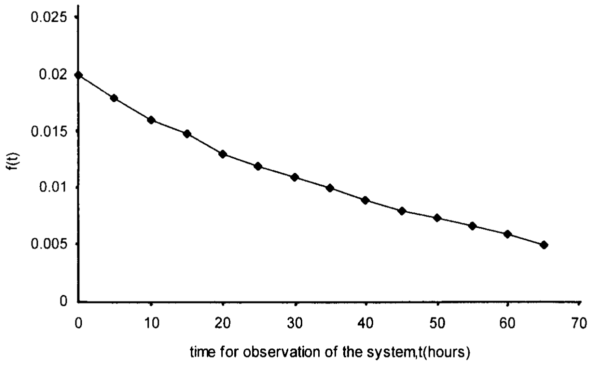

Fig.1. Diagram of density of distribution of the standstill of locomotive transport system in MHD.

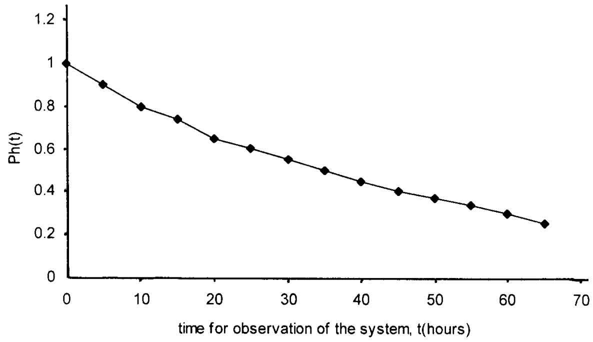

Fig.2. Diagram of plausability that no standstills of locomotive transport system will take place in MHD.

Plausability for continual work of the transport system or that no standstill will occur is expressed by the function (Ponomarenko, 1975):

$$P_h(t) = e^{-\lambda t} \quad (9)$$

in this case:

$$P_h(t) = e^{-0.02t} \quad (10)$$

The diagram shows that the increase of time for observation of transport sistem plausibility that it will operate with no standstills decreases.

Conclusion

The parameters for reliability of locomotive transport system in MHD allows us to conclude that it is little reliabile in accomplishing its function and needs further increase in order to increase its effects. Increase of reliability of transport system is related to increase in investment in facilities and plants.However, optimum reliability of the system should be found that would provide minimum utilization during performace taking in consideration costs for its reliability increase.

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