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AVAILABILITY OF TECHNOLOGICAL EQUIPMENT

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Abstract *The maintenance and repair systems are based on a logical scheduling of activities, simultaneously with the monitoring of operating behavior of equipment. The paper deals with the availability analysis for complex systems of equipment in large lignite open pits in Romania.*

Key words*: availability, reliability, maintainability open pit mining, excavator*

The availability, as a measure of the degree of good functioning and readiness to be used of equipment has two components: the reliability and the maintainability; any equipment supplier must nominate the value of the availability of given equipment. Meanwhile, the customer is obliged to perform in due time and correctly the maintenance and repair tasks. (fig.1).

The analysis of availability is based on the monitoring and measuring the real time devoted to maintenance in connection with the failure rate, for each individual equipment as for the entire technological line.

The meaning of notations used as follows is: A(t) - availability function; R(t)-reliability function; M-maintainability function; λ-failure rate; μ-number of repairs of an equipment in a given time period; t_r - repaire time period; MTBF - mean time between failures; MTR - mean time to repair; t - the functional time between failures.

In order to achieve a higher availability is the result of a set of measures devoted to lead to an increase of the effectiveness of assets usage in mining industry. A product is available if it is reliable and possesses an appropriate maintainability. Analyzing the relation between availability, reliability and maintainability we obtain the following relationship for the availability:

$$A(t) = R(t) + [1 - R(t)]. M \qquad (1)$$

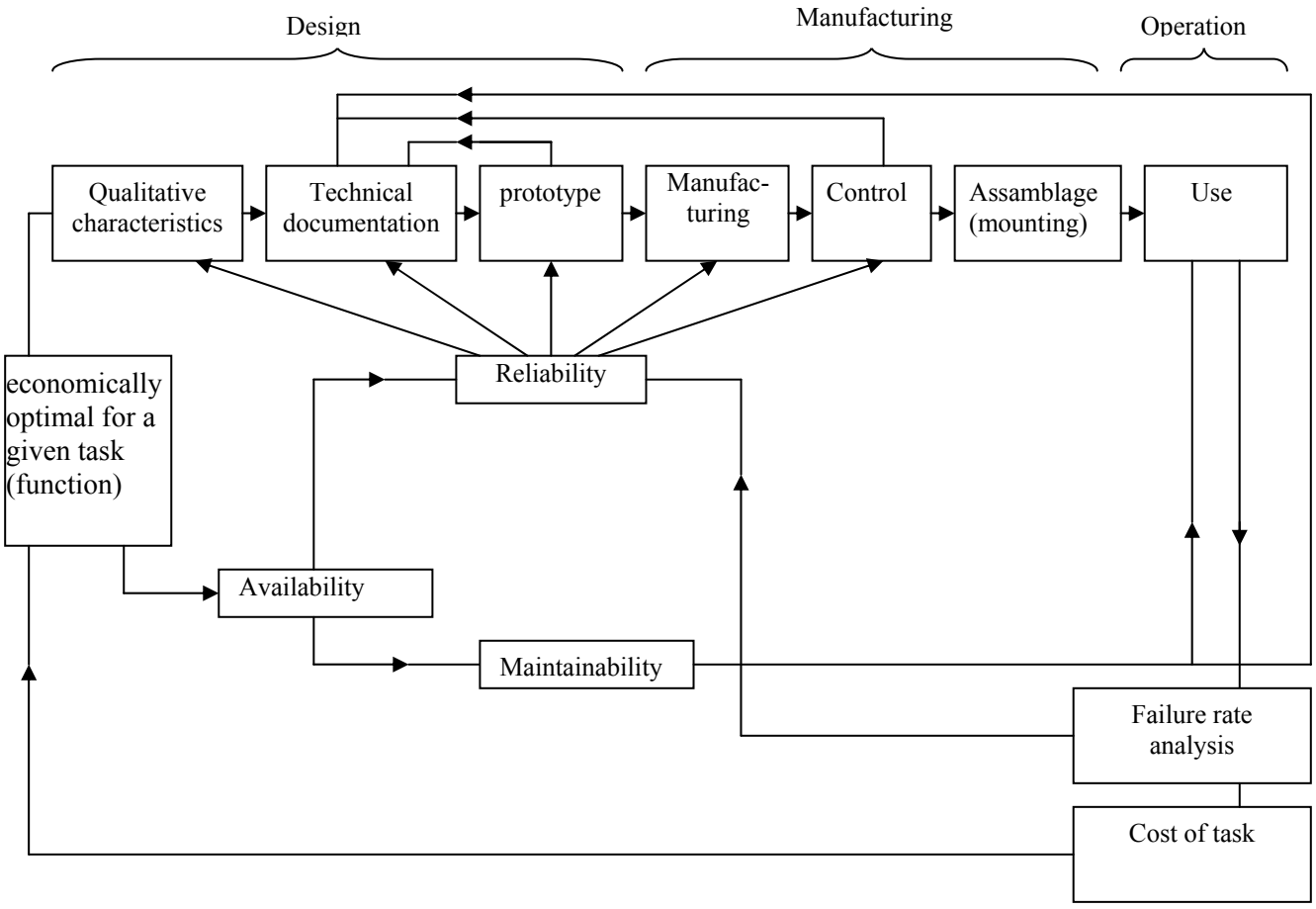

Fig. 1 Relationship between availability, reliability and maintainability

Considering an exponential repartition law the equation above became:

$$A(t) = e^{-\lambda t} + (1 - e^{-\lambda t})\,(1 - e^{-\mu\, tr}) = 1 - e^{-\mu\, tr}\,(1 - e^{-\lambda t}) \qquad (2)$$

As a statistical metric for expressing the availability we can use the factor of availability in the case pf exponential repartition law of the operation time (t_i) and repair time (t_r):

$$A = \frac{MTBF}{MTBF + MTR} = \frac{1/\lambda}{1/\lambda + 1/\mu} = \frac{\mu}{\mu + \lambda} \qquad (3)$$

The instantaneous values and the average values of the availability and unavailability for the systems for energy supply are determined on basis of time statistics.

The chronologic time (T_c) will be:

$$T_c = T_f + T_{mp} + T_{mc} \quad (4)$$

In which: T_f – the operation time

T_{mp} – the time of preventive maintenance

T_{mc} – represents the time of corrective maintenance

Availability (A_T) is determined from:

$$A_T(\%) = \frac{T_f}{T_c} \cdot 100 \quad (5)$$

The concrete analysis of availability was performed for three technologic flows belonging to the open pit mines from the Oltenia coalfield.

The structure of the three production lines was as follows:

- Technological line 1: excavator 1400, BRS ,two belt conveyors , bridge , spreader.

-Technological line 2: excavator 1300-02, BRS, upcoming plate, three belt conveyors , spreader (absetzer 6300x 96) .

- Technological line 3: excavator 47o-o3, CBS, upcoming plate, four belt conveyors, spreader (absetzer 6300 x 96).

In case of a system of „n" elements connected in series, the system availability will be:

$$A_S = \prod_{Li=7}^{12} A_{Li} \quad (6)$$

In which:

Li – months (7 -12).

Table 1: Technological line 1

Nr. crt.	**Availability Component specification**	**A_{L7}**	**A_{L8}**	**A_{L9}**	**A_{L10}**	**A_{L11}**	**A_{L12}**	**Average**
1.	Excavator + belts	0,43	0,61	0,57	0,46	0,58	0,61	0,54
2.	BRS	1	1	0,99	0,90	0,99	0,98	0,97
3.	Belt conveyor T1	0,98	0,97	0,97	0,96	0,97	0,97	0,97
4.	Bridge	1	1	0,96	0,98	0,98	0,97	0,97
5.	Belt conveyor T6	0,98	0,99	0,99	0,99	0,99	0,92	0,97
6.	Spreader	0,98	0,99	1	0,98	0,97	0,92	0,97
	Overall availability, A_S	0,40	0,57	0,52	0,37	0,52	0,49	0,48

The values of availability are given in tables for each equipment belonging to a technological lines 1, 2 and 3 (for a period of six months, starting with July).

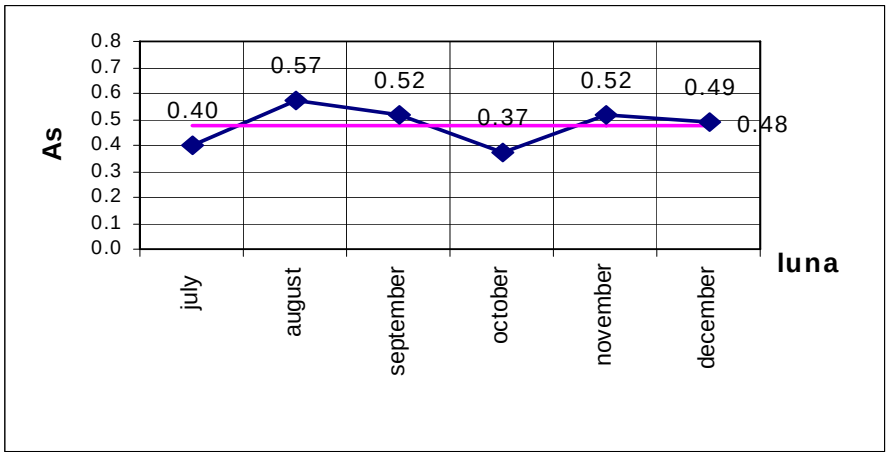

Fig. 2. Evolution of the availability of the system „Technological line 1"

Table 2: Technological line 2

Nr. crt.	Availability Element specification	A_{L7}	A_{L8}	A_{L9}	A_{L10}	A_{L11}	A_{L12}	Average
1.	Excavator + excavator belt	0,58	0,75	0,69	0,61	0,43	0,88	0,65
2.	BRS	0,99	0,99	0,99	1	1	1	0,99
3.	Incoming plate	1	1	0,93	1	1	1	0,99
4.	Belt conveyor T4	0,88	0,96	0,96	0,94	0,94	0,88	0,91
5.	Belt conveyor T2	0,68	0,65	0,92	0,87	0,64	0,87	0,76
6.	Belt conveyor T3	0,92	0,81	0,72	0,89	0,54	0,89	0,81
7.	Spreader ABZ 6300	0,92	0,94	0,93	0,85	0,94	0,89	0,90
	Overall availability A_S	0,29	0,35	0,37	0,37	0,13	0,53	0,32

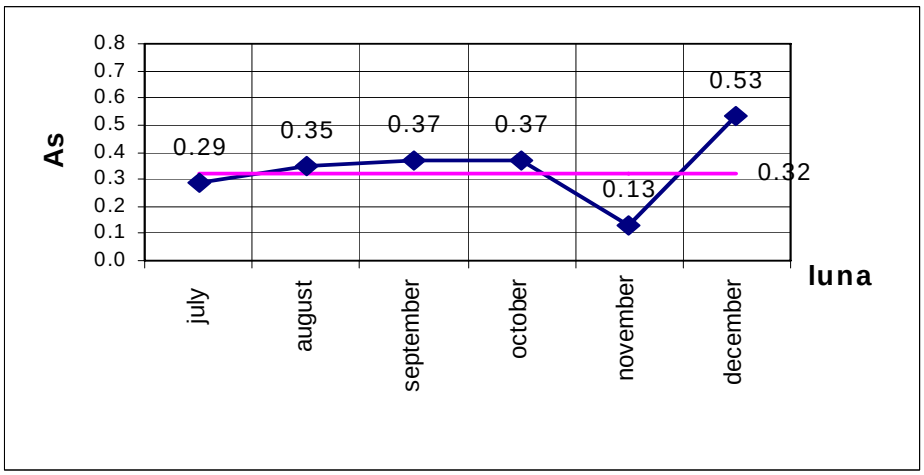

Fig. 3. Evolution of the availability of the system „Technological line 2"

Table 3:Technological line 3

Nr. crt.	Availability Element specification	A_{L7}	A_{L8}	A_{L9}	A_{L10}	A_{L11}	A_{L12}	Average
1.	Excavator + excavator belt	0,60	0,84	0,84	0,82	0,25	0,59	0,63
2.	CBS	0,95	0,93	0,90	0,98	0,90	0,62	0,89
3.	Incoming plate	0,99	0,98	1	0,99	1	0,97	0,99
4.	Face belt conveyor T4	0,86	0,95	0,96	0,95	0,90	0,95	0,93
5.	Belt conveyor T2	0,77	0,76	0,97	0,88	0,48	0,47	0,71
6.	Belt conveyor T3	0,95	0,77	0,71	0,91	0,65	0,88	0,83
7.	ABZ – 01Spreader	0,95	0,96	0,93	0,92	0,97	0,76	0,92
	A_S	0,33	0,40	0,46	0,55	0,06	0,10	0,27

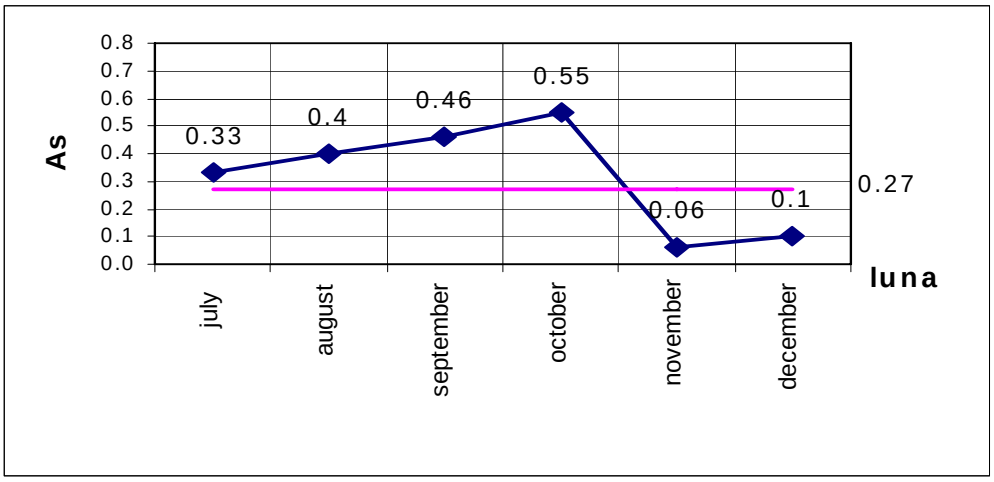

Fig. 4. Evolution of the availability of the system „Technological line 3"

In the figure 5 the variations of the availability for each excavator of the three technological lines are presented.

The availability factor of the overall system must have an average value preestablished of about 0.48. We notice that this is fulfilled only by the Technological line 1 (see fig. 2), line which is operating in coal and overburden.

The availability factor is relatively constant with no dramatic downgrading.

Not the same thing is true for the technological line 2, which operates only in overburden with an average value of the availability of 0,32 (see fig. 3). The low value of the availability is duet to the failure of crawler system in November. A more important decrease of the availability can be seen in the case of the technological line 3 (see fig. 4), which operates in overburden. The lowest value of the availability (0,06) is noticed in November and it is due to mechanical failures in the wheel gear system.

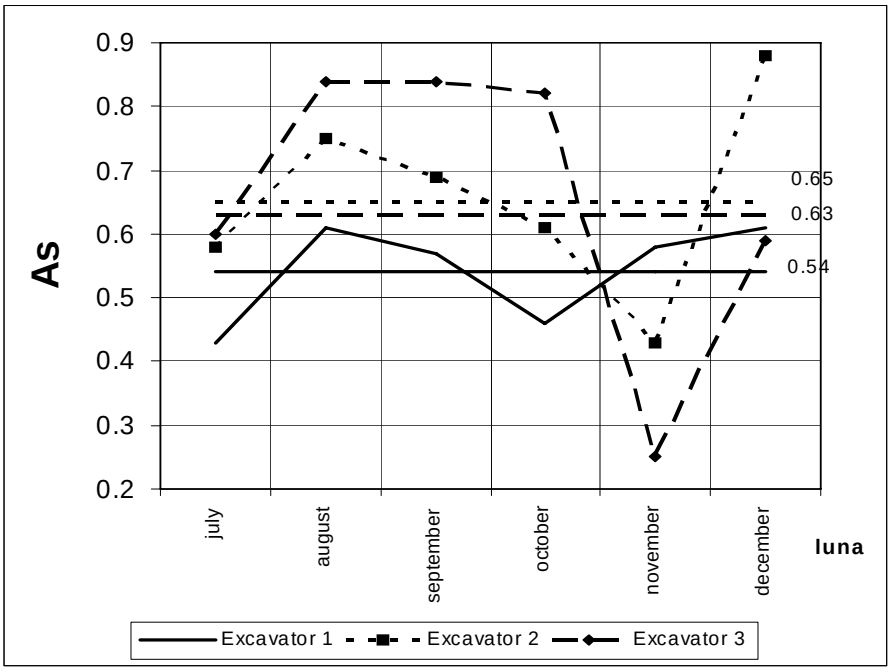

Fig. 5. Evolution of the availability of the excavators from the three technological lines

The overall availability of the equipment (see fig. 5), is constant in case of the excavator 1400-01, with a value of 0.54. We can notice the decreases of November for excavators 1300 and 470 (technological lines 2 and 3) with values of availability of 0.43 respectively 0.25 which caused low productivities of the two excavators in the given period of time.

We can notice that the lowest value of the availability appears in November and it is equal to 0.13; this value is due to dramatic failure of mechanical subsystems with high repair time requirement.

Mechanical failures of the excavators has highest repair time share, which implies the necessity to take into account the maintenance actions according to annual schedules in order to improve availability indicators for all components of open pits technological lines.

REFERENCES

Bercea, N. – Modernizarea si fiabilizarea utilajelor din dotarea CNL Oltenia, in Revista Minelor, Nr. 2/2002.

Florea, A. – Fiabilitate şi protecţia muncii, vol. 1. Fiabilitate, Litografia I.M.P. 1988.