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ECONOMIC ASPECTS OF THE MAINTENANCE OF AUXILIARY MECHANIZATION

EKONOMICKÉ ASPEKTY ÚDRŽBY POMOCNÉ MECHANIZACE

Abstract

The maintenance of auxiliary mechanization, in respect of dynamics and content of conducting procedures of preventive maintenance, should be very carefully apportioned and strictly adjusted to the real needs, because, in the contrary, some opposite effects may appear and significantly reduce reliability and effectiveness of auxiliary mechanization, with a considerable increase in expenses. Maintenance models are based on reliability parameters and optimization criteria of, most frequently, minimal costs and maximal readiness or are based on their compromises. Operation costs are in direct dependency on the selection of equipment for concrete conditions in open-pit working environment and engaged equipment production capacity.

The economic demands assume that, while constructing and exploitation of the machine, the amount of the used material should be as little as possible, as well as that of work and time in relation to the unit of product, i.e. production during the exploitation period of the machine in service. This paper presents software for controlling the efficiency parameters of auxiliary mechanization at lignite Open-pits in Serbia, i.e. the part which controls economic aspects and costs of maintenance. This software is developed to process data from three largest open-pits in Serbia: Kolubara, Kostolac and Kosovo. The software is tested in practice at big open pit and can be used in design of future open pits.

Abstrakt

Údržba pomocné mechanizace, v závislosti na rychlosti a objemu pochodů preventivní údržby, by měla být velmi pečlivě plánována a jasně upravována vzhledem k reálným požadavkům. V opačném případě může dojít k značnému poklesu spolehlivosti a efektivnosti zmíněné mechanizace se značným růstem nákladů. Modely údržby jsou založeny na spolehlivých hodnověrných parametrech a optimalizačních kritériích, především na minimálních nákladech a maximální rychlosti aplikace, popřípadě na jejich kompromisech. Provozní náklady jsou přímo úměrné výběru zařízení pro konkrétní podmínky v pracovním prostředí povrchových dolů a výkonnosti těchto používaných strojů.

Z pohledu ekonomických požadavků je jasné, že v době rekonstrukce a exploatace stroje musí být objem používaného materiálu co nejmenší, a taktéž objem práce a času v závislosti na jednotce produktu, tj. poměr mezi dobou exploatace (objemovým výkonem) a servisní dobou. Článek presentuje a popisuje software pro kontrolu výkonnostních parametrů pomocné mechanizace na povrchových lignitových dolech v Srbsku, jako prvek hlídající ekonomické aspekty a náklady údržby. Software je vytvořen pro zpracovávání dat ze tří největších povrchových dolů v Srbsku: Kolubara, Kostolac a Kosovo. Software je testován v praxi na velkých povrchových dolech a může být použit při navrhování nových povrchových dolů.

1 INTRODUCTION

The basic task that is, as a rule, set by modern systems (in this case to the auxiliary mechanization) is certainly the great extent of their efficiency and reliability of work. In recent years this field has been theoretically covered by a great number of works, however, its practical appliance has been absent on our open pits. The total features of the technical system, in the sense of the successful performance of the given work parameters, i.e. its set aim function, can be best expressed through the

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efficiency function of the system. Namely, the efficiency of the system refers to the ability of the system to perform the function it is intended for, including the frequency of the failures, difficulties occurring during the repairs and maintenance, as well as the capability of the system to perform the function when working in accordance with the conception of the construction.

Taking into account a great number of factors affecting reliability and the fact that they are all changeable in time, it is more rational to look for the support for the calculation of parameters of reliability in the statistic control of the parameters of the work of the machine. Namely, statistics is an inductive method according to its nature and it starts from some hypotheses, but the conclusions are made on the basis of experience, facts, events and statistical experiments. It is an empiric method as such, it presents one of the numerous approaches of creating new and making proof of existing knowledge, on a large field of scientific research. That is the reason why it is possible to forecast numerous parameters on the basis of the well-known values i.e. on the basis of the previous data of the work of the same or similar machines from the same group of the machines of auxiliary mechanization.

2 INDICATORS OF THE WORK EFFICIENCY

The basic indicators of the efficiency of the work of the system are not the same with all processes, systems, machines, constructions, aggregates, but they differ among themselves, and are selected depending on the criterion for the efficiency evaluation. As the basic parameters of the efficiency of the work of the system we can mention:

- reliability,
- readiness,
- availability,
- suitability of maintenance.

The data about the indicators of the work efficiency can be reached in three ways:

- forecasting - on the basis of the well-known parameters of the similar machines or systems,
- examining in a laboratory - examining the models with equivalent characteristics,
- on the basis of following the data out of exploitation.

By all means the best and of the greatest quality way for the calculation of the indicators of the efficiency of the auxiliary mechanization is the calculation on the basis of following the data out of exploitation. A big problem with this way of calculation of the indicators is a great number of data that are followed and impossibility of their processing without the support of complex informative systems and using computer equipment.

Because of the necessity of following and researching the parameters of the efficiency of the work of the auxiliary mechanization on open pits of lignite the software PoPom has been made. The basic data that have been used in this program are those about the realized time of the work of the machines (resource), as well as the data about the duration of the failure of the machines i.e. the stoppage time because of the service and because of the repairs of the machine. The program has been made in the program language Visual Basic 5.0., for the operative system Windows NT/95. The basic of the data that is used in the program has been made in MS Access. The basic panel of the program PoPom is showed in the Figure 1.

The fourth part of the PoPom Program may be opened from the initial panel (Figure 2) after entering the field „Maintenance of machines“, whereby a 3-subforms panel is opened:

1. types of reparations and repairs,
2. maintenance costs,
3. costs of occupancy and operation.

The program consists of four connected units in which some basic and derivative parameters of the efficiency of the work of the auxiliary mechanization are followed and calculated as well as the unit in which the maintenance of the auxiliary mechanization is followed and planned, i.e. performing some repairs and preventative operations with the aim of constant functional preparation of means and taking care of production equipment and other working means.

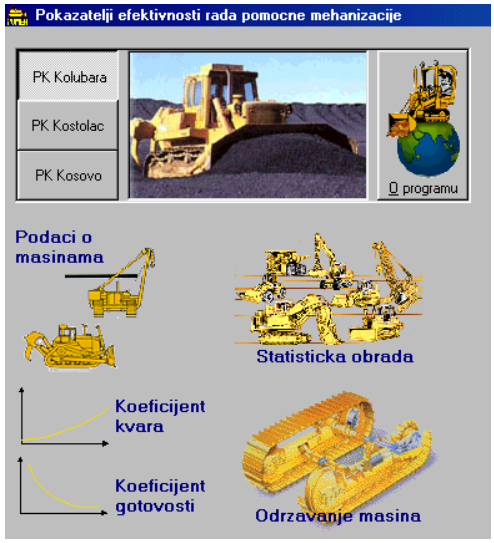


Fig. 1 Basic panel of the program PoPom

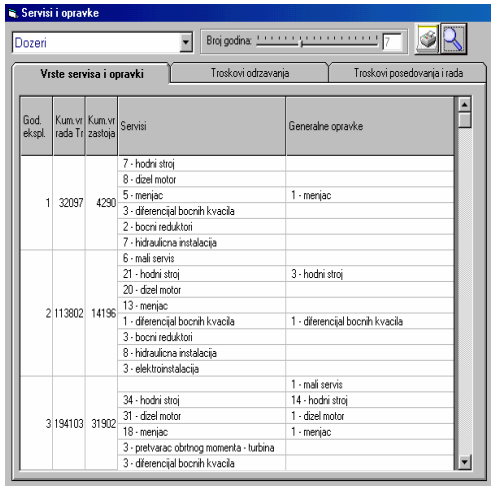
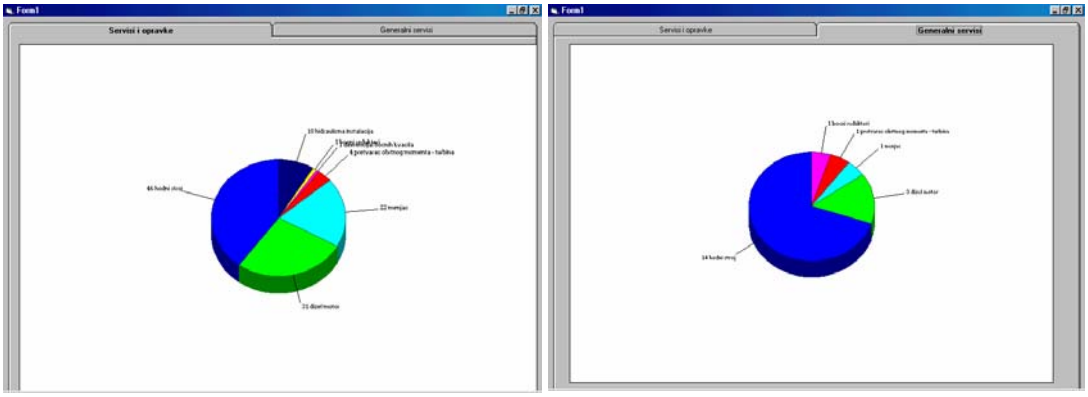


Fig. 2 Panel Machine Maintenance with three subpanel

3 TRACKING WEAK POINTS

The first subform „Types of reparations and repairs “ is intended for tracking weak points on a machine, by tracking the number of failures of particular elements and assemblies of the whole machine. Namely, the „PoPom“ Program calculates (on the basis of templates in the first form) the number of performed repairs and general overhauls on all machines in the certain period and for the certain time of operation of machines. Panels are shown in Figure 3. In the panels, the reparations and repairs are separated from general overhauls by various sub forms.



Reparations and repairs *General overhauls*

Fig. 3 Graphic overview of weak points on machine after four years of operation

From the panels above we may clearly see which assemblies are the most threatened, after how many years and after how many hours of operation. In addition to the statistical tracking of weak points on a machine in this form it is also possible to plan spare parts in a certain measure. More exactly, a maintenance person clearly sees from the obtained tables and diagrams in which assembly (part) of the machine a repair or general overhaul has been made in the first, second etc. year of operation or for which number of hours of operation, so such person may suppose which assembly is the most threatened in order to make plans for spare parts, so as not to give rise to the maintenance costs due to the lack of or waiting for spare parts.

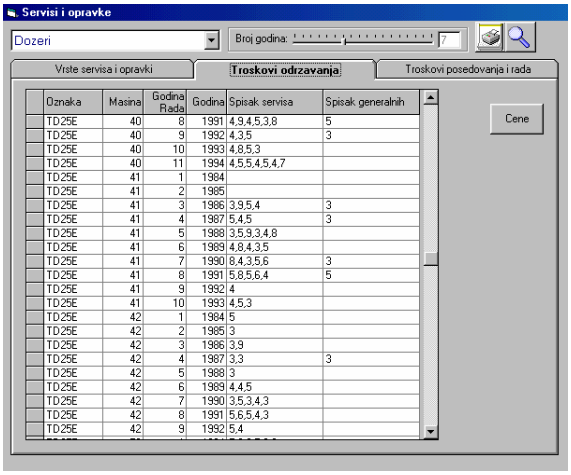
4 MAINTENANCE COSTS

The basic table in the panel „Maintenance costs“, contains an overview of all machines of auxiliary mechanization in an open-pit mine, with its labels, number, year of operation and year of its introduction into the production. There are also coded lists of reparations and repairs and general overhauls in the basic table, which enable us to clearly see which reparations and repairs were performed, in which year for each machine.

The panel also contains the field „Prices“, intended for opening the panel for the calculation of maintenance costs. Entering the field „Prices“ opens the subform „Installed parts“. The panels are shown in Figures 4 and 5.

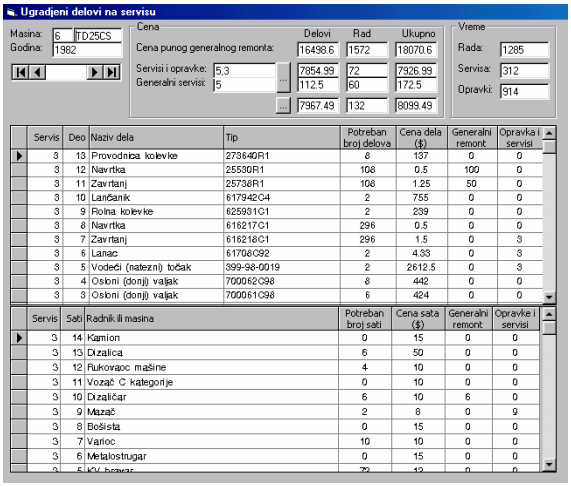
By filling in the last two columns in tables, i.e. by entering the data on actual number of employed spare parts and working hours for reparations, repairs and general overhauls, which are tracked by the maintenance service, the program, depending on the number of employed parts, calculates and displays the following:

1. cost of spare parts and cost of working hours used for reparations and repairs and their total cost, for the year in which the research was made,
2. cost of spare parts and cost of working hours used for general overhauls and their total cost, for the year in which the research is made,
3. total Cost of spare parts and cost of working hours used for reparations and repairs and general overhauls, for the year in which the research was made,
4. total maintenance costs of the machine for the year in which the research is made (total cost of spare parts, consumable material and equipment, as well as the cost of working hours of the engaged staff and machines).



Oznaka	Masina	Godina Rada	Godina	Spisak servisa	Spisak generalnih
TD25E	40	8	1991	4,9,4,5,3,8	5
TD25E	40	9	1992	4,3,5	3
TD25E	40	10	1993	4,8,5,3	
TD25E	40	11	1994	4,5,5,4,5,4,7	
TD25E	41	1	1984		
TD25E	41	2	1985		
TD25E	41	3	1986	3,9,5,4	3
TD25E	41	4	1987	5,4,5	3
TD25E	41	5	1988	3,5,9,3,4,8	
TD25E	41	6	1989	4,8,4,3,5	
TD25E	41	7	1990	8,4,3,5,6	3
TD25E	41	8	1991	5,8,5,6,4	5
TD25E	41	9	1992	4	
TD25E	41	10	1993	4,5,3	
TD25E	42	1	1984	5	
TD25E	42	2	1985	3	
TD25E	42	3	1986	3,9	
TD25E	42	4	1987	3,3	3
TD25E	42	5	1988	3	
TD25E	42	6	1989	4,4,5	
TD25E	42	7	1990	3,5,3,4,3	
TD25E	42	8	1991	5,6,5,4,3	
TD25E	42	9	1992	5,4	

Fig. 4 Basic panel of the subform "Maintenance costs"



Servis	Deo	Naziv dela	Tip	Potreban broj delova	Cena dela ($)	Generalni remont	Opravka i servisi
3	13	Provodnica kolevke	273640R1	8	137	0	0
3	12	Navrtka	25530R1	108	0.5	100	0
3	11	Zavrtanj	25738R1	108	1.25	50	0
3	10	Lančanik	617942C4	2	755	0	0
3	9	Rolna kolevke	625931C1	2	239	0	0
3	8	Navrtka	616217C1	296	0.5	0	0
3	7	Zavrtanj	616218C1	296	1.5	0	3
3	6	Lanac	61708C92	2	4.33	0	3
3	5	Vodeći (natezni) točak	399-98-0019	2	2612.5	0	3
3	4	Oslonj (donji) valjak	700062C98	8	442	0	0
3	3	Oslonj (donji) valjak	700061C98	6	424	0	0

Servis	Sati	Radnik ili masina	Potreban broj sati	Cena sata ($)	Generalni remont	Opravke i servisi
3	14	Kamion	0	15	0	0
3	13	Dizalica	6	50	0	0
3	12	Rukovaoc mašine	4	10	0	0
3	11	Vozač C kategorije	0	10	0	0
3	10	Dizaličar	6	10	6	0
3	9	Mazač	2	8	0	9
3	8	Bošista	0	15	0	0
3	7	Varioc	10	10	0	0
3	6	Metalostrugar	0	15	0	0

Fig. 5 Basic panel of the subform "Prices – Installed parts"

5 TOTAL COSTS, REVENUE AND PROFIT

In the last form „Costs of occupancy and operation" particular economic parameters are treated in a simplified manner, and such parameters may be treated at this level of tracking and calculating the ratios of operation efficiency related to the auxiliary mechanization. Entering into the subform „Costs of occupancy and operation" enables opening the panel showed in Figure 6. The panel is displayed after entering necessary data and with calculated values of costs of occupancy and operation for one machine in the period of one year.

Values which are to be entered into the panel „Costs of occupancy and operation" were grouped in such a way that, after entering values of particular prices and costs, being with the company's economic department, the final cost of occupancy and operation for one machine, as well as its revenue at annual level, on the basis of a mathematical model.

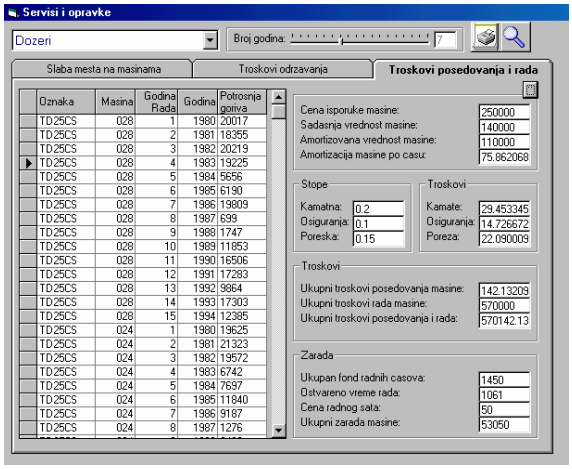
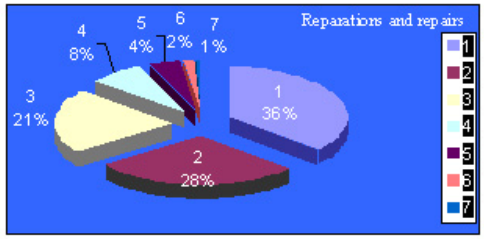


Fig. 6 Panel with calculated values of "Costs of occupancy and operation" for machines

6 REPORTS OF THE POPOM PROGRAM

Each form of the PoPom Program has the option "Print" which is intended for printing entered and treatment-obtained data.



1 Employed machine	48
2 Diesel engine –	37
3 Gear box -	28
4 Hydraulic installation –	10
5 Lateral reducer –	5
6 Turbine –	2
7 Lateral clutches Differential	1

MAINTENANCE COSTS

Year	1	2	3	4	5	6
Machine revenue ($)	41150	104750	102950	97550	85750	69350
Maintenance costs ($)	10500	49500	86600	106000	109000	111000

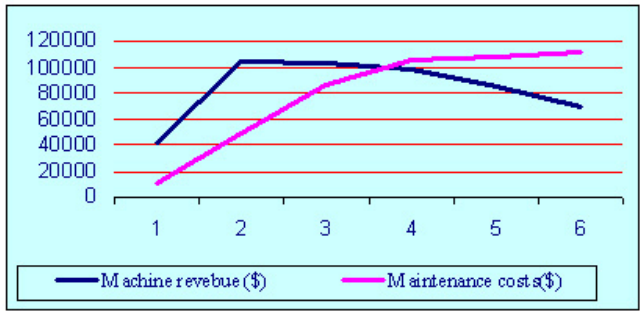


Fig. 7 Printed Report of the "PoPom" Program

The Report 4 provides also a diagram of maintenance costs and revenues of machine. A special emphasizing is needed on a considerable lack of data necessary for the calculation of these parameters, and which are required for the accuracy of the calculation by the PoPom Program. Namely, the Program requires precise keeping records of the usage of all spare parts, as well as working hours spent for reparations, repairs and general overhauls. Precise records keeping and entering of those data into the program provide very accurate values of maintenance costs related to auxiliary mechani-

zation, both to individual machines and all groups of machines of auxiliary mechanization in an open-pit mine. In addition to precise entering the data on used spare parts and spent working hours of machines, accurate data of the economic department of the open-pit mine, related to the values of interest, tax and insurances rates, are necessary for the calculation of costs of occupancy and operation of machines.

The diagram of maintenance costs and machine revenues is made on the basis of calculated middle values of realized working hours, middle values of delay hours and known values for used up spare parts and equipment as well as spent operation time for repairs and reparations, for certain number of machines, and it is not an absolutely accurate ratio of these two values, but it is exemplary enough, with respect to the number of available input data. As we may see in the Diagram, the maintenance costs are constantly increasing, and then decreasing, firstly due to the oldness and then due to lower level of maintenance. The critical year in which the diagram of maintenance costs intersects the diagram of cost of revenue is the fourth year of the exploitation of a machine. On the basis of these considerations, we may conclude that a machine should be used as more as possible in the first four years of operation so as to make the investment profitable, because after that period, a question of operation productivity of the machine arises, as well as cost effectiveness of the investment in the maintenance of such machine.

7 CONCLUSION

Besides many mistakes and disadvantages within the organization of the maintenance of the equipment on our open pits, in recent years the methods of maintenance based on scientific knowledge have been more and more applied. This has been affected by the knowledge of the extremely great influence of the strategy of maintaining the equipment on the total efficiency of the work of an open pit.

Apart from the fact that a lot of data concerning the work, stoppage, interventions etc. about the auxiliary mechanization are noted, some absence in the systematization of managing and presentation of the those data is evident. This program thus serves for the following all the data on one pit as well as for the following and processing the parameters of the efficiency of the work of the machines from the group of the auxiliary mechanization.

By the program "PoPom" many laws of the work of dozers on the open pits of lignite in Serbia have been determined. These laws can be used both for optimum exploitation and efficient maintenance of the existing auxiliary mechanization and for the correct choice of the new auxiliary mechanization.

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