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MAINTENANCE DATA EVALUATION

The paper briefly describes and demonstrates the possibilities of processing, utilization and evaluation of computer maintenance system based data with the aim of increasing of quality and effectiveness of maintenance system. The data in the example were obtained from machine works which uses computer maintenance management for last three years. The presented example is focused on evaluation of maintenance records from point of view of maintenance management system. An emphasis is put on continuous corrections of the maintenance system resulting in its improvement and elimination of weak points.

***Keywords**: Maintenance; Maintenance Data Evaluation*

1. Introduction

Implementation of maintenance quality management system into businesses in the Czech Republic brings among others unprecedented possibilities of data analysis, which are documented and electronically stored within the maintenance management system. The basic requirement for the maintenance quality system is the complete documentation of all essential system information – it must be clearly stated when, who, how and with what tools and instruments is any particular maintenance operation to be performed, the information on who and when performed the maintenance and the costs records of particular maintenance operations must be traceable etc. The stored maintenance data are routinely used for maintenance planning and various operational analyses of maintenance system – e.g. for analysing cost-efficiency, labour consumption or length and quantity of downtimes of selected object in reviewed time period, for calculation of total monthly maintenance costs for individual departments or production lines in the company, for analysing failure rates of individual machines in order to eliminate causes of frequent failures etc.

2. Example of Company Maintenance System Evaluation

The data obtained from a machinery engineering company's maintenance management are evaluated in the presented example. The company commenced to establish a quality system in the beginning of the year 2000. The maintenance management software was purchased in spring of the following year and the maintenance department started to use it after the implementation period on a regular basis in autumn 2001. Following data were collected during a year period from March 2002 to February 2003. As it can be seen from the below mentioned data, although the maintenance department was intensively using the maintenance management software, the data were not analysed with the aim of feedback and system correction. This is an example of undesirable maintenance system development.

The maintenance system evaluation is then performed by assessment of expected system benefits, which we require of the effective system in first years after its implementation. The main benefits of the system can be summarized in the following points:

a) the ratio of not planned to planned repairs will change significantly to the benefit of planned repairs
b) thus in a long-term horizon the total maintenance costs will decrease and production efficiency will increase because of the increase of machinery availability, elimination of downtimes etc.
c) this is related to the expected decrease of downtimes and need of expensive spare parts, which are used extensively after breakdowns
d) the significant reduction of repeated failures resulting from the documented data of machine failures and their analysis
e) the expected growth of the production equipment's total efficiency related to b), c) and d)

The total of 5562 maintenance events were recorded to the database of performed maintenance events during an evaluated season (5475 events not planned and 87 planned). The database concerned maintenance events of 326 machines and 48 maintenance workers employed in the company. It is already obvious from this general data, that maintenance system is not properly adjusted – planned maintenance events are rather exception amounting roughly 1,5 % (it is the case of revisions and inspections performed externally in the company). In average 15 failures were fixed by

maintenance events everyday. The basic information on maintenance events in the reviewed period are given in the Tab. 1.

conclude, that just a very small number of all provided maintenance events is documented in the system.

Furthermore, let us try to analyse a trend of partial

Tab. 1 Information on maintenance events in the reviewed period

	3_2002	4_2002	5_2002	6_2002	7_2002	8_2002
Maintenance costs	260 073	237 320	355 520	487 222	344 147	917 740
Number of maintenance events	342	381	456	552	539	592
Planned maintenance events	6	6	0	3	2	12
Maintenance labour consumption	845	862	798	1 075	1 116	1 399

9_2002	10_2002	11_2002	12_2002	1_2003	2_2003	Total
779 700	1 021 080	1 176 005	814 023	1 317 060	966 242	8 676 132
527	529	543	507	473	434	5 875
5	17	4	6	20	6	87
1 265	1 335	1 270	924	1 531	1 051	13 471

At first, from the presented data it is evident, that it took quite a long time before the maintenance workers started to input data into the system really seriously – all performed maintenance events were certainly not recorded until May 2002 and even until July 2002 the information about the used material was not input together with the maintenance event record, which results in low values of maintenance costs, although the number of corrective maintenance events is comparable. For this reason it is not possible to seriously evaluate the trend of maintenance costs for the whole reviewed period, because the cost data are not correct at least until 7/02. The costs slowly rise during the period from 8/02 to 2/03; considering the trend of labour consumption and number of maintenance events we can see the reason in the gradually improving approach of the maintenance workers to the completeness of the maintenance events recordings in the database.

The major problem of the described maintenance system is that there is not even a slight shift from corrective maintenance towards planned maintenance. Therefore maintenance costs, labour consumption and number of maintenance events do not show required trends. The maintenance costs (if we do not consider the already discussed initial period) are still around 1 million CZK a month.

The figures of maintenance labour consumption fluctuate around 1200 hours a month, expected declining trend is hardly evident. The average monthly labour consumptions of documented maintenance events offer also further useful information about how the data was input into the system – when dividing an average monthly labour consumption by a number of maintenance workers (there were 48 maintenance workers employed in the company), each maintenance worker worked out just 25 hours a month. We can

downtimes, which started to be monitored in the company at the end of the year 2002. Downtimes (in hours) during monitored months are showed in Fig. 1.

From the presented downtimes data it is obvious, that maintenance or organizational downtimes do not indicate the expected decreasing trend. The impact of changed warehouse management system in July 2002, which caused chaos of stock items delivery for two months, can be seen in the graph. It is evident, that although the downtimes were quite truly documented in the databases, the data were not analysed by the maintenance department and no necessary actions to reduce the downtimes were carried out. The downtimes trend is of course related to the already mentioned fact, that corrective maintenance are still prevailing in the company.

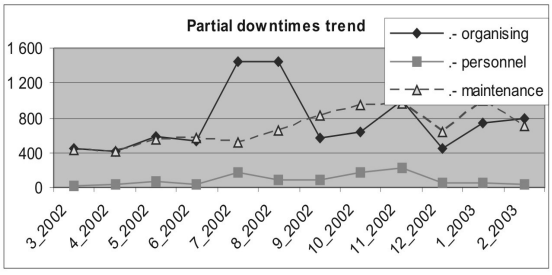

Fig. 1 Partial downtimes trend

Another possible way of processing the long-term documented maintenance data is the failure mode analysis (especially of repeated failures) focused on their considerable reduction. In Tab. 2 are presented the most significant failures from the cost point of view, Tab. 3 presents the failure frequencies.

Tab. 2 Costs of elimination of causes of selected failures

quarter:	2Q 2002	3Q 2002	4Q 2002	1Q 2003	total
Main hydraulics	47 160	2 374	105 521	15 432	170 487
Mechanical failure - generally	124 330	489 120	385 050	338 900	1 337 400
Electro failure - generally	79 080	439 180	184 418	499 940	1 202 618
Mechanical - spindle	121 290	216 350	282 780	60 230	680 650
Control electronics	40 790	12 904	64 380	21 370	139 444
Position sensors	88 711	39 680	119 100	102 690	350 181
Electro motors	33 360	63 440	88 820	62 940	248 560
Not classified failures	6 370	16 680	208 511	2 737	234 298
Total costs of monitored failures	541 091	1 279 728	1 438 580	1 104 239	4 363 638
Costs of all failures	854 210	2 016 320	2 785 230	2 756 200	8 411 960
% of costs of monitored failures out of the total failures costs	63,3 %	63,5 %	51,7 %	40,1 %	51,9 %

When we leave aside "general" causes of failures (Mechanical failure – generally, Electro failure – generally), which include a number of further not specified failures, the most unfavourable failures from the costs point of view are indicated as "Mechanical – spindle" and "Position sensors". If the maintenance system is analysed properly, the head of the maintenance department should deal particularly with these failures and introduce adequate measures to decrease substantially the occurrence of these costly failures. Especially the cost effects of the "Mechanical – spindle" failure are very high despite of relatively low occurrence. As can be seen from the presented tables and graph, this kind of failures was finally reduced in the beginning of 2003. In the reviewed period the causes of the "Position sensors" failure were not evidentially identified nor reduced. In the end of 2002 the maintenance manager focused on the monitored failures and the situation was partially amended (see the last row of Tab.2 "% of costs of monitored failures out of the total failures costs"), however, according to the fluctuations of costs and failure occurrence, the need for more efforts in this area is evident. The maintenance manager's active effect on maintenance workers, aiming to more specific classification of a given failure in the failure code list, is evident from the rows "not classified failures", "mechanical failure – generally" and "electro failure generally". There are just 2 not classified failures in the first quarter 2003 and the number of failures with "general" causes also gradually declines.

For the most important machines, according to their failure rate, the more detailed view, with the focus on causes of the repeated failures of a particular machine, is of great importance. Machines, which need to be inspected this way, can be easily filtered out by listing out machines in descending order according to the amount of the costs of not planned maintenance events in a specific period. The records of machines with the highest costs need to be analysed – it is necessary to verify particularly not only the assigned failures codes, but also the added notes referring to the maintenance events. A fragment of more detailed maintenance descriptions of one of the machines are stated in Tab. 4 – often simple notes of maintenance workers are published without any corrections.

The table shows rather frequent case in the company, that the corrective maintenance is concerned on repairing of constantly repeating failures, while the primary cause is not being solved in time. In the

Tab. 3 Occurrence of monitored failures

	2nd q.2002	3rd q.2002	4th q.2002	1st q.2003	total
Main hydraulics	41	6	31	22	100
Mechanical failure - gen.	191	564	442	320	1 517
Electro failure - generally	240	669	329	240	1 478
Mechanical - spindle	**17**	**26**	**29**	**13**	**85**
Control electronics	39	14	14	3	70
Position sensors	**61**	**22**	**82**	**45**	**210**
Electro motors	29	40	55	26	150
Not classified failures	12	14	17	2	45
Monitored failures in total	630	1 355	999	671	3 655
				Total number of failures:	5 476

Tab. 4 Extract of the maintenance workers' notes about carried out maintenance

date	*17.11.2002*	*19.11.2002*	*21.11.2002*	*24.11.2002*	*28.11.2002*	*13.12.2002*	*17.12.2002*	*11.1.2003*
worker's note	*water in oil of spindle hydraulics*	*shortage of oil in hydraulics*	*shortage of oil in hydraulics*	*shortage of oil in hydraulics...*	*oil filled in...*	*low oil level, oil refilled*	*water in hydraulics, filter exchange, tank cleaned*	*water in hydraulics, filter and oil exchange, tank cleaned*

given example the maintenance workers were eight times repairing a failure in hydraulics of a particular machine, without dealing with the cause of the failure (it seems that the maintenance worker wanted to say "as usually" by dots at the end of the notes made on 24.11. and 28.11.). However, according to the maintenance documentation, the cause was finally eliminated on 22. 1. 2003, when the note says: "Exchange of rotten hydraulic hose and seal ring". The failure does not repeat again since this maintenance was performed; however, it could have been eliminated 2 months earlier.

3. Conclusion

The purposeful processing of long-term documented maintenance data can provide plenty of information not only about a machine's history, but also about its maintenance system. The main objective of data analysis is to continually improve the maintenance efficiency, which is closely related to improvements in dependability and overall productivity of the production equipment. Further examples of evaluation of maintenance management data can be found in [2].

4. References:

[1] JurčaV., Hladík T., Aleš Z.: *Možnosti využití a zpracování dat z řízení údržby (Possibilities of utilizing and processing of maintenance data)*. Monograph, Czech Society for Quality, Prague, 2004, ISBN 80-02-01595-9.

[2] Legát V., Jurča V.: *Management jakosti v údržbě (Quality Management in Maintenance)*. Monograph, Czech Society for Quality, Prague, 1999.

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