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ANALYSIS OF TEROTEHNOLOGY INFLUENCE ON TECHNICAL SYSTEMS AVAILABILITY DURING WARRANTY PERIOD

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ABSTRACT
Terotechnology is multydiscipline technology, which is dealing with all techno-economical parameters and astivities of technical systems, during its lifetime cycle, from the begining - economical studies and projects, over design, construction, installation, adaptation, maintenance and modernization, exploatation and control, to the replacement and its discard, in order to minimize total costs during complete lifetime of system, with return flow of information.
In this presentation, it will be presented analysis of technological maintenance aproach influence on technical systems availability during adaptation period ie. warranty period.
Keywords: analysis, terotechnology, availability, technical systems

1. INTRODUCTION
Brown Coal Mine "Banovići" in Banovići in recent years made significant step forward in changing production strategy. There has been made analysis of production equipment condition and reliability. Acording to that analysis, there have been made projects of technical and economical justifiability of investments in the existing equipment or purchasing of a new equipment. It was defined equipment in which is justified to invest in the next period, and at the same time, it was made proposal of purchasing new equipment. After that, there was purchased new equipment (hydraulic excavators, dump trucks, buldozers, greders, drilling machines, etc.), where significant investment was made.
In this project, it is presented for one technical system (hydraulic excavator RH 120E), according to its time frame condition (operating and breakdown data – event genesis), analysis of influence of terotechnology approach to maintenance for available technical systems during break-in period ie. during warranty period,.

2. THEORETICAL RESEARCH

2.1. Basic terms and definition
Terotechnology approach to maintenance is related to combination of management, finances, engineering and other practical experiences, applied to material properties, in order to achieve economical expences in their lifetime cycle [1].
Terotechnology is science discipline which explores methods and function of permanent material systems or technical systems during their lifetime period [4].
Terotechnology is relatively new term, introduced in 1970 year in Great Britain. Word terotechnplogy has its roots in Greek word TEREO, which has more meanings: to take care, to keep, which is been cared, to be kept, to keep from something, to keep on eye etc.). According to definition regulated in British standards, terotechnology contain combination of managing, technical, financial and other

activities, applied to material recourses, in order to achieve minimum expences during their exploatation, ie. during their life time.
Within terotechnology, there are studied design problems of technical systems, regarding reliability and maintainability, including all activities related to assembly, commisioning, maintenance, modernization and replacement of technical systems [1].
Availability function is defined as probability that system will operate in the moment of time t, compering to reliability function, which represents probability of system operation in the time interval 0 to t. Technical systems availability analysis, as probability that technical system will be activated in given moment of time, ie. when it is expected, is very important in production process.
In [1] system availability represents probability that system will be capable to operate properly in any moment of time, ie. to be activated for operation.
According to excavator purchasing contract, availability is defined in following equation:

$$GRM = \frac{RS - \sum PZM - \sum NZM}{RS} \cdot 100\,\%$$

Where is:
GRM – guaranted excavator availability, ie. portion in percentage of available hours (RS) when excavator is operating or ready to operate (when excavator is fully functional, but can not operate because of end user error: no available operator, no work to do, excavator damage caused by inapropriate operation, and inpossible excavator servicing caused by lack of spare parts which is caused by end user).
RS – number of available hours during one year, required in tender by excavator end user.
$\sum PZM$ - planed excavator breakdowns, which includes regular maintenance and regular services, recomended by excavator manufacturer.
$\sum NZM$ - unpredictible excavator breakdowns, caused by unpredictible failures, but not those caused by end user workers or by act of good (breakdowns which are not included in regular maintenance and regular services, recomended by manufacturer according to operating condition, breakdown analysis, excavator preparation for breakdown elimination, delay in delivery of parts for services caused by deliverer, excavator testing after conducted service for eliminating unpredictible breakdown).
To Apply terotechology aproach in equipment maintenance during warranty period to proof availability, it means to use and maintain technical (installation of original spare parts) systems according to manufacturer instruction.

3. EXPERIMENTAL RESEARCH

3.1. Experiment plan

Research is conducted on open pit «Cubric» of coal mine «Banovici», on hydraulic excavator TEREX RH – 120 (1). For target function implementation, it has been done following: There was defined technical system (excavator), there were defined research parameters, there were defined breakdowns, there were defined causes of breakdowns, it was defined condition time frame with analysis of influence to terotechnology approach to maintenance on excavator availability in observed period of time.

3.1.1. Condition timetable

The base for analysis of terotechnology influence on technical systems availability is condition timetable ie. genesis of events. Technical systems condition timetable enables for observed period of time, determination of following: number of conditions («OPERATING» and conditions «BREAKDOWN», condition period, cause of breakdown by its type, size, direction of breakdown cause effect and other parameters in function of necessity and in function of installed information system.
System condition timetable depends (with all other conditions) of system design and level of design complexicity. Colected and processed data are presented in table 1.

Table 1. Operation and breakdown data of hydraulic excavator TEREX – RH 120

	AVAILABLE HOURS UPON CONTRACT	EXCAVATOR RH 120 E – 1000 TEREX - 1		
		PZM (h)	NZM (h)	GRM (%)
From 10th of May 2006.	333	17	43	81,98
June	500	19	48	86,60
July	500	4	14	96,40
August	500	31	57	82,40
September	500	13	2	97,00
October	500	2	218	56,00
November	500	13	31	91,20
December	500	7	10	96,60
January 2007.	500	2	14	96,80
February	500	4	234	52,40
Mach	500	20	3	95,40
April	500	9	21	94,00
To 10th of May 2007.	167	0	6	96,41
FIRST YEAR OF WARRANTY	**6000**	**141**	**701**	**85,97**
From 10th of May 2007.	333	0	13	96,10
June	500	6	48	89,20
July	500	2	172	65,20
August	500	11	25	92,80
September	500	3	21	95,20
October	500	8	57	87,00
November	500	3	3	98,80
December	500	17	339	28,80
January 2008.	500	2	173	65,00
February	500	0	217	56,60
March	500	1	134	73,00
April	500	3	12	97,00
To 10th of May 2008.	167	2	22	95,20
SECOND YEAR OF WARRANTY	**6000**	**58**	**1236**	**78,43**
From 10th of May 2008.	333	6	45	84,68
June	500	5	42	90,60
July	500	4	87	84,68
August	500	7	51	88,40
September	500	0	525	0,00
October	500	1	234	53,00
November	500	4	34	92,40
December 2008.	500	1	132	93,40
January 2009.	500	5	263	46,40
February	500	0	60	88,00
March	500	1	24	95,00
April	500	6	253	48,20
To 10th of May 2009.	167	0	15,5	90,71
THIRD YEAR OF WARRANTY	**6000**	**40**	**1765,5**	**69,91**

In the purchasing contract for excavator, it was defined warranty time for complete excavator for period of 5000 operating hours, while warranty for excavator steel frame is for period of 10000 operating hours.

It is also defined in contract availability of excavator:

- in the first year of excavator operation 90 % or 5400 operating hours,
- in the second year of excavator operation 85 % or 5100 operating hours, and
- in the third year of excavator operation 82 % or 4920 operating hours.

The base for availability calculation is 6000 operating hours per one year with condition for end user to purchase only original spare parts from manufacturer or its dealer in the period of guaranteed availability. It is necessary to emphasis that excavator purchasing contract precisely mentioned procedures for defining GRM.

It is clearly noticeable from table 1 that during warranty period (period of proving availability) it is not achieved guaranteed availability even for one year (first year 85,97%<90 %, second year 78,43 %<85 %, and the third year 69,91 %<82 %)
The main reason for not achieving guaranteed availability, are high values of time NZM (first year 710 hours, second year 1236 hours, and the third year 1765,5 hours – table 1).
After detailed analysis of time NZM structure, it was given conclusion that the biggest influence on these time periods is delay in spare parts delivery. Analysis showed that it was given up from purchasing original spare parts, as it is defined in purchasing contract, and it was lost warranty, what has very bad consequences for excavator end user.

4. CONCLUSION

Analysis of terotechnology influence in technical systems maintenance on technical systems availability during warranty period, in given case in certain period of operation, presented more weaknesses, what resulted in reduced excavator availability.
Even it is defined in excavator contract (where is clearly noticable terotechnology approach) all procedures (activity algorythms) for excavator operation and maintenance during warranty period, it is clearly noticable that there are not conducted all procedures.
In this project is given one more try to emphasise justification for applying terotechnology approach in technical systems maintenance, in order to reduce maintenance costs.

5. LITERATURE

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