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OIL QUALITY INFLUENCE ANALYSIS ON CONDITION OF HYDRAULIC EXCAVATOR RH 120E TRIBOLOGY ASSEMBLIES

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ABSTRACT
Determination of tribology assemblies condition has very important part in development of theory and practice of friction, wear and lubrication. Recently, special attention is paid in development of modern equipment and methods for monitoring of change tribology systems condition. Nowdays, different physical-chemical methods are used for wear diagnosis.
Experience in technical systems and mechanism exploitation proved that prediction of malfunction (proactive maintenance approach) is the most effective, based on parameters which are reliable indicators of wear process – particles which are result of wear.
Analysis of physical – chemical characteristic of oil, enables in the early phases of system use to evaluate influence of oil quality change on tribology assemblies condition.
In this document, it will be presented results of experimental research which are conducted on equipment (hydrostatic power systems of hydraulic excavator RH 120E) in brown coal mine Banovici.

Keywords: Dijagnoza, tehničko stanje, tribološki sistem, bager RH- 120-E

1. INTRODUCTION

Tribology diagnosis as collection of means and methods for continuous control of friction characteristics condition of mobile assemblies has bigger importance in development of friction, wear, and lubrication theory and practice. Exploitation of technical systems,and mechanisms, proved that the moste effective way for their malfunction prognosis is based on particles which are formed by wear. Analysing oil samples which contain particles, formed by wear, alowe in different phases of tecnical system exploitation to evaluate condition of tribomechanical systems. Generaly, particle concentration in sample and its distribution by dimensions show wear speed and level of wear. Normal operatin conditions show equal concentration of small particles. Suden appearence of big particles in oil imply begining of cotastrofic wear process [1].

2. EXPERIMENTAL RESEARCH

2.1. Experiment plan

Research is conducted on open pits of coalmine „Banovici" on technical systems (excavators) Terex RH-120-E (internal designation 1 and 2), with shovel capacity of 15 m^3.
To achieve target function, it has been done following: it is defined technical system, it is defined tribology system, there are defined research parameters, there are definedacceptable limits, it is defined time frame for taking oil smples, there are defined oil testing methods, there are defined testing tools, it is conducted oil test, it is processed testing results, it is maade analysis of measured values-comparation with limit values to be able to make decision about further activities of maintenance department and to make conclusion.

2.2. Definition of technical systems

This Terex hydraulic excavator is part of big Terex mining equipment range. Years of experience in construction equipment production, modern design and production techniques, rigorous testing procedures and the highest quality demands, guarantee reliability and operative availability of Terex hydraulic excavators.

Excavator Terex RH-120-E is 6,27 m wide, 10,27 m long (without shovel nad boom), shovel capacity 15 m3, powered by electric motor with power of 1044 KW, power is transmited form electric engine by two stage splitter box, which is connected to electric motor with flexible couplings (Picture 1, table 1).

Picture 1. Excavator TEREX RH-120-E

Table 1. Excavator technical characteristics

Drive engine output	1044 KW
Frontal tablespoon (SAE 2:1) capacity of	15 m^3
Maximum digging force of	1370 KN
Maximum rupture force	920 KN
Width slippers gusjeničnog transport chain	1000 mm
Operating weight excavator	283 tons
Ground pressure	21,2 N/cm^2
The total quantity of oil in the hydraulic system of	3500 liters
The capacity of the hydraulic tank	2500 liters
Maximum working pressure	310 bars
Maximum pressure in the transport of	370 bars
Maximum pressure in a circular motion	350 bars
Maximum oil flow	426 l/min
Maximum speed was	5,1 rpm
The maximum transport speed of	2,7 km/h

2.3. Definition of tribology systems

Concerning the fact that is installed on technicall system (excavator) „TEREX RH-120-E“ large number of tribology systemsm, experimental research is diagnosis of tribology system technical condition, which are parts of hydrostatic power transmissions related to loading / unloading, swing function of uppercarriage, and excavator trawel system. This excavator is using high quality hydraulic oil for lubrication and and energy transmision from source to user.

2.4. Definition of oil testing methods

a) For determination of physical – chemical oil characteristics:

- Kinematic viscosity (mm^2/s) on temperatures 40 ^oC and 100 ^oC - testing conducted according to standards BAS ISO 3104 i DIN 51562,
- Viscosity index – testing conducted according to standards BAS ISO 2909 i ASTM D 2207,

b) For determining metal content (Fe, Cu, Al, Pb) (mg/kg – ppm) – testing conducted according to standard ASTM D 5863 i.e. it is applied atomic and apsorption spectometry.

2.5. Experiment results

Analysis of hydraulic oil, which results are presented, was done after failure of main hydraulic pump No. 2. After disassembling damaged hydraulic axial piston pump, it was found one piston damaged, what is presented on Picture 2.

By analyzing hydraulic oil, the goal was to determine level of oil contamination to prevent new failures of hydraulic system components.

After failure of hydraulic pump No. 2, what was one of reasons for analysis of oil physical-chemical characteristics, in hydraulic system was oil HLV 100 super max (non genuine oil) which operates for

4813 working hours. In table 2 are presented results of genuine oil analysis (filled during machine assembling) and analysis of non genuine oil, manufactured in the region.

Table 2. Analysis results

			HVL 100		TM Long Term Hydraulic Fluid - TEREX		recommendations
			New oil	4813 h	New oil	5000 h	DIN 51524-3
The presence of metal in the oil due to wear							
Fe	mg/kg		0	3	0	13	
Cr	mg/kg		0	1	0	0	
Al	mg/kg		0	0	0	0	
Ni	mg/kg		0	0	0	5	
Cu	mg/kg		0	2	0	0	
Pb	mg/kg		0	0	0	0	
Mo	mg/kg		0	0	0	11	
Changes in physical properties of oil							
viscosity at 40	mm²/s		99,53	77,15	48,7	49,49	48,7
viscosity at 100	mm²/s		12,8	9,76	9,3	8,12	9,3
viscosity index			125	105	149	136	180
Presence of metals in the additives							
Ca	mg/kg		22	1	58	48	
Mg	mg/kg		0	0	0	0	
B	mg/kg		0	0	0	0	
Zn	mg/kg		15	55	410	340	
P	mg/kg		121	130	330	315	
Ba	mg/kg		0	0	0	0	

Picture 2. Damages of pump No. 2 elements

After given result of oil analysis and its comparison to limit values of individual characteristics, it was decided that complete oil in the system should be replaced. (total quantity of new filled oil 3500 lit.).
It was conducted complete analysis of damaged hydraulic pump, and it is decided that pump repair is not worth, compairing it with price of new pump (price of new axial piston pump is 38.000 €, while manufacturer offered to exchange damaged pump for new one for 50% price of new one. It is purchased and installed new pump. It is necessary to emhasize that excavator was not in operation because of pump for 336 working hours, what significantly increased total costs.
After replacing oil, excavator operated 350 working hours (with new oil) when happened „MALFUNCTION“ condition because of damage in boom cylinder mechanism, which is presented on Picture 3.
Cylinder has been dissasembled and analysed and conclusionwas that it is not possible cylinder regeneration in mine workshop, ans it was purchased new cylinder from abroad (new cylinder cost is 87.000 EUR). It is necessary to emphasise that excavator was not in operation for 144 working hours, what significantly increased total costs.
After 1134 working hours of operation with new oil HVL 100, it is noticed extreme hydraulic oil foaming, and oil samples were sent for chemical charactristic analysis. For reliable analysis, oil analysis was ordered form three different intitutes – oil testing laboratories. Analysis results from all three companies shoved the same results which shoved that used oil does not comply with characteristics required by standard DIN 51524-3 (main difference is in values of viscosity index what is essential for quality excavator RH-120-E operation).

Picture 3. Damages of boom cylinders

After confirmation of facts it was conducted hydrauli oil exchange with oil which was made specialy for brown coal mine „Banovici“ and based on required characteristics, and that is oil ISO VG 46 with viscosity index above 100 which operated very well in conditions in which excavators TEREX RH-120-E are operating.

3. CONCLUSION

In last few years, Brown col mine «Banovici» made significant investments for purchasing new equipment. Among all other equipment, there has been purchased two new hydraulic excavators RH-120-E, which were subject of these research. These research proved that it is necessary to apply terotechnology approach [3] for maintenance of these excavators. It means it is necessary to take special attention to maintenance of such expensive and high productive machine.

It is noticable that it was not payed attention on manufacturer recomendation when purchasing oil for hydraulic systems.

Consequences are big total expences which are calculated as sum of sum of direct and indirect expences. Direct expences are 125.000 €, and indirect expences are significantly higher, taking into account the fact that excavator was malfunction 480 hours, what caused seriously less coal production, considering its capacity.

Also, during excavator exploitation it was not take care of manufacturer recomendation for oil analysis every 500 working hours.

Further research should be focused on making oil program analysis, especialy if considering presence of mechanical impurities in oil, and based on that determining condition of tribology assemblies of these excavators hydraulic subsystems. It means transition in steps from reactive approach (solving consequences) to proactive approach in maintenance, ie. solving causes of condition „malfunction“ of mentioned technical systems.

4. REFERENCES

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