Possibility of hydraulic fluids application in agricultural tractors

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Abstract: *This paper presents the results of possibility of hydraulic fluids application in agricultural tractors. This test was performed on the Zetor Forterra 114 41 tractor and CASE IH Magnum 315 tractor. In the hydraulic circuit of the Zetor Forterra 114 41 tractor was applied the Mol Farm UTTO Synt oil and in the hydraulic circuit of CASE IH Magnum 315 was applied the Multagri Pro Tec oil. The test was carried out on the basis of a ferrographic analysis and cleanliness code by ISO 4406 of oil samples. The aim of a ferrographic analysis and cleanliness code by ISO 4406 is to identity the quantity and size of wear particles in oil samples.*

Key words: *Ferrographic analysis, cleanliness code, wear particles, hydraulic circuit.*

INTRODUCTION

Hydraulic equipment is widely used in powerful mechanisms of agricultural and forest machines as well as in many other areas. The development of modern hydraulic components is aimed at increasing the transmitted power, reducing the energy intensity, minimizing the environmental pollution and increasing the technical life and machine reliability (Tkáč et al., 2008)

At the present time, hydrostatic systems are widely dispersed in the industry. They provide various types of motions. The power transmission is performed by means of hydraulic fluid. Hydraulic fluid needs service and observation of operating parameters (Majdan et al., 2008). From the viewpoint of hydraulic fluid utilization in a machine, it is important to know the operating characteristics of a fluid, i. e. to know the effect of fluid on the technical condition of hydraulic system components (Tkáč, 2008 et al., Jablonický, 2007 et al.).

In working device the fluid transfers the energy and also carries the information about process in it. Into the fluid during the device operation entrance metal particles through which is possible to evaluate a wear process and predict the next operation of the device. Particle contamination in hydraulic fluid accelerates wear of system components (Casey, J, 2011). Therefore is very important to pay attention to purity of hydraulic fluid which is used (Tkáč et al., 2012). The fluid should be replaced if the value exceeds the limits, which are specified by manufacturer. The most common hydraulic fluid contaminants are water and air, along with particles of metal, rubber or dirt (MTS, 2012).

Possibilities of hydraulic fluids application were performed on the tractor Zetor Forterra 114 41 and tractor CASE IH Magnum 315. MOL Farm UTTO Synt oil was applied in the tractor Zetor Forterra 114 41 and Multagri Pro Tec oil was applied in the tractor CASE IH Magnum 315.

FERROGRAPHIC ANALYSIS OF OIL

The aim of a ferrography analysis is to identify the quantity and size of wear particles in oil samples. Wear particles have a significant effect on the abrasive wear of friction pairs in gear-hydraulic circuits of tractors. These contaminants degrade the hydraulic oil used. Pollution particle, despite oil filters located in the tractor gear-hydraulic circuit, should continue to grow during the operating. These particles tend to agglutinate during the operating and aggregate into large particles.

The Mol Farm UTTO Synt and MULTAGRI PRO TEC oils were diluted before ferrography analysis in proportion of 2:1 with tetrachlorethylene to better highlight of pollution particles in the oil. The MA 1 magnetic analyzer (Figure 1) and KAPA 6000 Microscope (Figure 2) were used for the ferography analysis of samples oil. The technological procedure of ferrography analysis was carried out in the laboratory of the Department of Transport and Handling, Faculty of Engineering, Slovak University of Agriculture in Nitra.

Fig. 1 MA 1 magnetic analyser

Fig. 2 KAPA 6000 microscope

CLEANLINESS CODE OF OIL

The fluid contamination is evaluated according to cleanliness code. The cleanliness code can be determined by standards: ISO 4406 – 1999, SAE AS 4059 or NAS 1938. The cleanliness code of hydraulic fluid per ISO 4406 is determined by counting number and size of particles in the fluid. The old ISO 4406 – 1987 defines the cleanliness code of particles lager than 5 μm and 15 μm according to two numbers X1/X2. X1 defines number of particles lager than 5 μm and X2 defines number of particles lager than 15 μm. In 1999 both, the definition for particle counting and the definition of ISO code was changed. ISO 4406 – 1999 defines cleanliness code according to particle sizes larger than 4 μm, 6 μm and 14 μm (Sauer, 2003, Kročko, et al., 2008).

The CS 1000 states cleanliness code by continual method i.e. the device is connected to hydraulic circuit during its work. Device uses optical detection of counting number and size of particles. Results of measurement are recorded by PC connected to device by analog interface RS 485. The basis conditions for connection of CS 1000 device to hydraulic circuit are as follow (Kročko et al., 2008):

- connection to suction or pressure pipe of circuit,
- flow rate of fluid must be from 30 ml . rpm to 300 ml . rpm,
- kinematic viscosity max. 1000 $mm^2 . s^{-1}$,
- fluid pressure max. 10 MPa.

Diameter of inlet pipe must be smaller than 4 mm and output pipe lager than 4 mm.

RESULTS AND DISCUSSION

The following oil samples of MOL Farm UTTO Synt oil were studied: samples of a new oil, and oil samples after completing 450 engine hours and after completing 900 engine hours.

The following oil samples of Multagri Pro Tec oil were studied: oil samples after completing 500 engine hours, and oil samples after completing 1,500 engine hours, and oil samples after completing 2,000 engine hours, and oil samples after completing 3,500 engine hours and oil samples after completing 5,000 engine hours. These samples were from five the same type tractor at different operational time.

Figure 3 shows the ferrography images of MOL Farm UTTO Synt oil samples. These images were created 400 times magnification with camera Moticam 1000 and microscope Kappa 6000.

Figure 4 shows the ferrography images of Multagri Pro Tec oil samples. These images were created 400 times magnification with camera Moticam 1000 and microscope Kappa 6000.

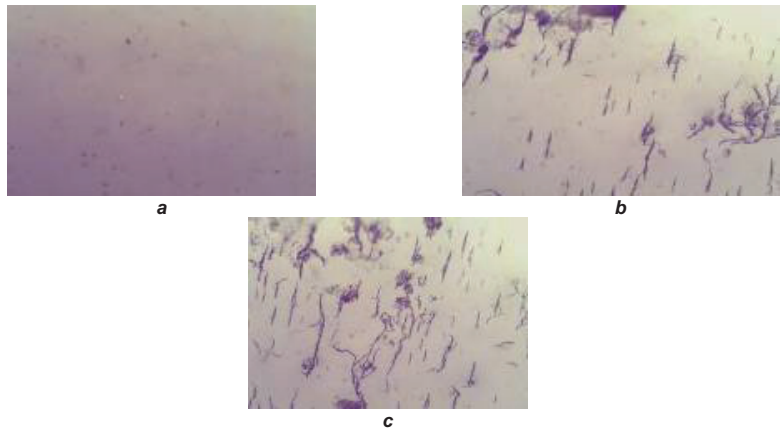

Fig.3. Wear particles in the MOL Farm UTTO Synt oil samples (a – new oil, b – 450 engine hours, c – 900 engine hours)

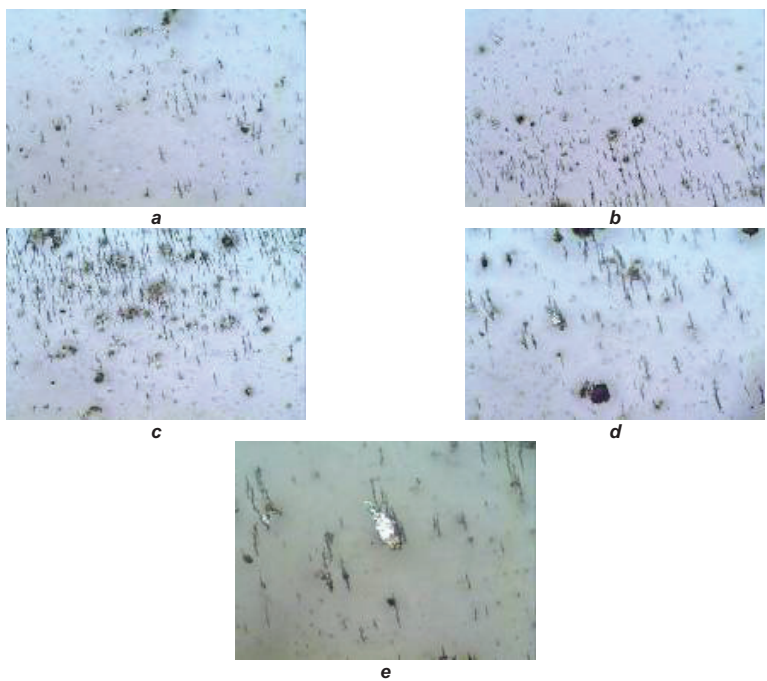

Fig.4. Wear particles in the oil samples (a - 500 engine hours, b - 1,500 engine hours, c - 2,000 engine hours, d - 3,500 engine hours, e - 5,000 engine hours)

In the samples of unused MOL Farm UTTO Synt oil, there were practically found no pollution particles. After completing 450 engine hours, oil samples contained wear particles of no more than 10 μm. At the same time, there were also clusters of small wear particles that have no negative impact on the transmission hydraulic circuit of the Zetor Forterra tractor. After completing 900 engine hours, oil samples contained large clusters of small wear particles and large particles, too.

From the ferrography images of Multagri Pro Tec oil samples result that the samples after 500 engine hours 1,500 engine hours and 2,000 engine hours are not virtually visible wear particles. In the oil samples are only small chains of particles. The tractors after 3,500 a 5,000 engine hours again show the small chains of particles, but in oil samples were found visible wear particles. The comparison with catalogue of wear particles we have found that their are particles of adhesives wear, which means that the gear-hydraulic circuits of tractors CASE IH Magnum 315 after completing defined engine hours are in running state of wear.

Table 1 shows the results from measuring of cleanliness code according to ISO 4406 with CS 1000 device.

Table.1.

Evaluation of measurements cleanliness code

	Cleanliness code by ISO 4406		
	> 4 µm	> 6 µm	> 14 µm
MOL Farm UTTO Synt			
0 engine hours	23	22	18
450 engine hours	23	22	15
900 engine hours	24	22	16
Multagri Pro Tec			
500 engine hours	20	18	12
1,500 engine hours	18	16	13
2,000 engine hours	17	15	13
3,500 engine hours	17	15	13
5,000 engine hours	17	15	14

From the findings resulting that the gear-hydraulic circuit of Zetor Forterra 114 41 tractor show no the technical or technological failing. On the basis of measurements of cleanliness code it can by stated that the tractor after 900 engine hours is in running state of wear.

The evaluation of cleanliness code shows that in samples of Multagri Pro Tec oil from tractor after 500 engine hour is highest contents of particles > 4 µm and > 6 µm. From other samples is the cleanliness code in defined intervals lower and after 2,000 engine hours, 3,500 engine at 5,000 engine hours show the number of > 4 µm particles the value 17 and the number of > 6 µm particles the value 15. The tractor after 500 engine hours showed the number of > 14 µm particles the value 12. The highest value of the number of particles 14 was detected in a tractor after 5,000 engine hours. The biggest production of wear particles in intervals > 4 µm and > 6 µm was at tractor after 500 engine hours because his gear-hydraulic system was in running. In interval of > 14 µm is in all tractors higher the number of particles, what indicating the operational wear.

CONCLUSION

Based on the analysis of ferrographic images and comparing with the catalogue of wear particles, it was found that the gear-hydraulic circuit of the Zetor Forterra 114 41 tractor is in the process of wear.

From the findings resulting that the gear-hydraulic circuits of analysing tractors show no the technical or technological failing. On the basis of measurements of cleanliness code it can by stated that the tractor after 500 engine hours is in running state of wear because was determined the higher amount of wear particles in intervals > 4 µm a > 6 µm. During ferrography analysis was not discovered the large particles. In tractor after 5,000 engine hours were detected the particles that were smaller than 20 µm. That speaks about the operational wear of gear-hydraulic circuit of tractor CASE IH Magnum 315 after completing 5,000 engine hours.

In terms of ferrography, we recommended the fluid to be filtered in order to extend its technical life. At the present time, a new filtration device is therefore being designed at the Department of Transport and Handling, Faculty of Engineering, Slovak University of Agriculture in Nitra.

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Докладът е рецензиран.