The durability test of tractor hydrostatic pump type UD 25 under operating load

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The results of the UD 25 hydrostatic pump durability test are presented; they were obtained in the laboratory under operating load. The test of operating load was a continuation of the hydrostatic pump durability test with a cyclic pressure loading according to the norm STN 11 9287. It lasted 300 hours, with 70°C ± 2°C of hydraulic fluid temperature. The aim of the test was to simulate the operation of the hydrostatic pump under load in laboratory and to find out its deterioration and the influence of a biodegradable fluid on its qualities. The achieved results confirmed that flow efficiency of the UD 25 hydrostatic pump decreased only to 3.6% which points to its good technical state even after the test performance. Meanwhile we can state that the used ecological hydraulic fluid on the basis of a vegetable oil "Environmentally responsible tractor transmission oil", produced by the Slovnaft company, Inc., is characterised by very good qualities.

Keywords: hydrostatic pump; operation load test; simulation; flow characteristics; ecological fluid

The environmental protection forced the users and producers of a mobile technology to fulfill challenging requirements imposed on ecological hydraulic systems that come into the contact with the environment. At present, almost 50% of all the oils sold in the world finish as forfeits during the operation in nature (Jakob, Theissen 2006). A small biological degradability of its particles presents a considerable threat for the environment. That is why it is important to substitute mineral oils by biodegradable fluids.

The aim of this paper is to perform a durability test of a tractor UD 25 hydrostatic pump with an operating load in laboratory and to achieve hydrostatic pump parameters, on the basis of which we can characterise a change of its technical qualities when using biodegradable fluids.

MATERIAL AND METHODS

To simulate the operating load it was necessary to suggest and realize a testing device to be used in laboratory. For this purpose it was first necessary to achieve time courses of pressures on the output of tested UD 25 hydrostatic pump. The time courses of loading pressures were achieved by the measurement in a hydraulic system of the Zetor Forterra 114 41 tractor while plowing in a set with a 5-PHN 30 plough within a strength regulation (Tkáč et al. 2006). The measured time courses of the pressure loading were exposed to the analysis from both amplitude and frequency view. On the basis of the performed analysis it was possible to judge the adequacy of the suggested and realised testing device for the simulation of the operating load in laboratory. In Fig. 1 a scheme of a

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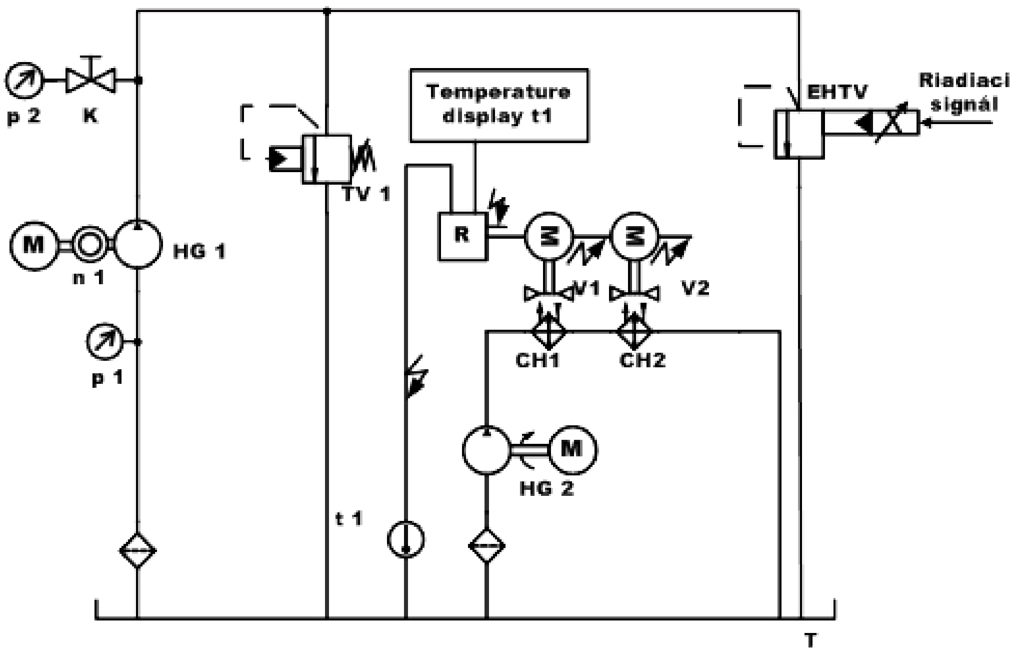

Fig. 1. Scheme of the testing device (Petranský et al. 2004):
M – electric motor, n 1 – rpm sensor, HG 1 – tested hydrostatic pump, TV 1 – two stage sequence valve for adjusting nominal pressure in the outlet of hydrostatic pump, p 1 – pressure gauge of pressure in the inlet, CH 1, CH 2 – coolers, p 2 – pressure gauge of pressure in the outlet, EHTV – proportionally operated sequence pressure valve, K – spherical plug valve, T – tank, R – thermostatic regulator, HG 2 – hydrostatic pump for cooler, t 1 – temperature sensor for tank, V 1, V 2 – fans

testing device was suggested with reference to works by Drabant et al. (2005), Tkáč et al. (2008a), and Kročko et al. (2008).

The durability test with the operating load was realised at the Department of Motor Vehicles and Heat Devices, Technical Faculty of the Slovak University of Agricultural in Nitra. Fig. 2 depicts a view of a testing device in laboratory.

On the testing device the time courses were simulated; they were achieved on the output of the hydraulic hydrostatic pump under the operation conditions while plowing. The chosen time course is depicted in Fig. 3.

Fig. 2. Testing device for durability test by operating load

Time changes of course pressures in hydraulic system in output hydrostatic pump are exemplified in Fig. 3. By ploughing with Zetor Forterra 114 41 tractor with 5–PHN 30 plough (Fig. 4), output hydraulic pressures oscillate from 1 to 6.5 MPa. Measured courses of pressures demonstrate that hydraulics used in the tractor with 5–PHN 30 plough is sufficient. Tkáč et al. (2004) measured the amplitudes of pressure in output hydrostatic pump; ZTS 164 45 tractor with 5–PHX 35 plough at ploughing gave the values from 1 to 8 MPa, whereas ploughing with KUHN plough resulted in amplitudes of pressure from 1.5 to 9 MPa. ZTS 164 45 tractor has bigger amplitude pressure because ploughs have one ploughshare more and the tractor has bigger delivery. Yet, we can establish that our results are comparable to the results with the ZTS 164 45 tractor (Tkáč et al. 2004; Cvíčela et al. 2008).

The testing device was operated and run by a computer control system. The block scheme of the control system is depicted in Fig. 5.

The basic blocks of the control system were the personal computer with the D/A converter off-set and an ERJ electronic control unit. The operation alone of the

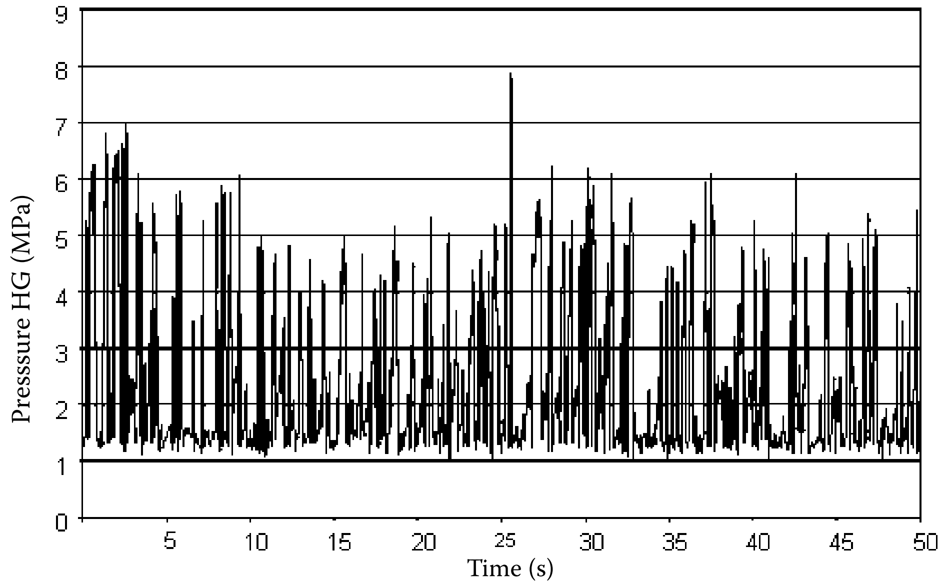

Fig. 3. Outlet pressure of hydrostatic pump measured during the operation of Zetor Forterra tractor with 5-PHN 30 plow

Fig. 4. Zetor Forterra 114 41 tractor with 5–PHN 30 plough

electrohydraulic proportional pressure EHTV valve was realised with a digital-analogical converter D/A and an ERJ electronic running unit. The converter D/A converted digital signal of computer into analogue signal, the pressure running U_R was a time function. The analogue signal $U_R = f(t)$ was subsequently amplified in an ERJ electronic control unit and transported on a EHTV proportional pressure valve.

As a filling, the MOL Tractol ERTTO oil, a biologically degradable hydraulic fluid, was used; it was produced by the Slovnaft company, Inc. The technical data of the oil are depicted in Table 1 (Slovnaft company, Inc. 2007).

In order to find out the influence of the hydraulic fluid on the qualities of the hydrostatic pump, it was necessary to measure the flow characteristics.

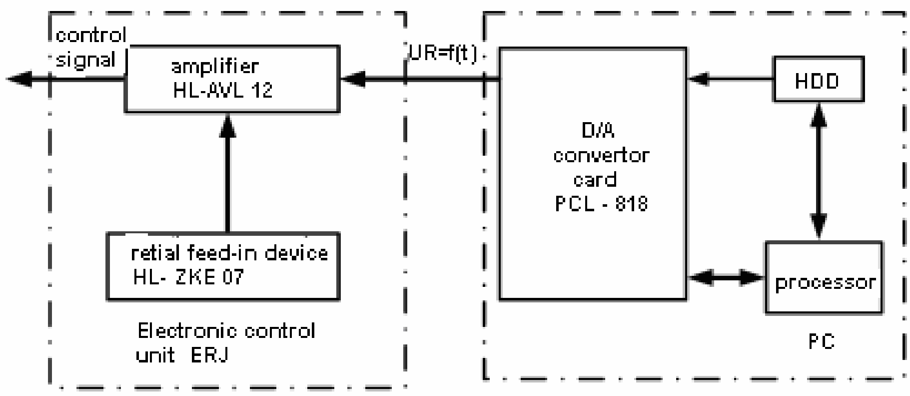

Fig. 5. Block scheme of control system for testing device

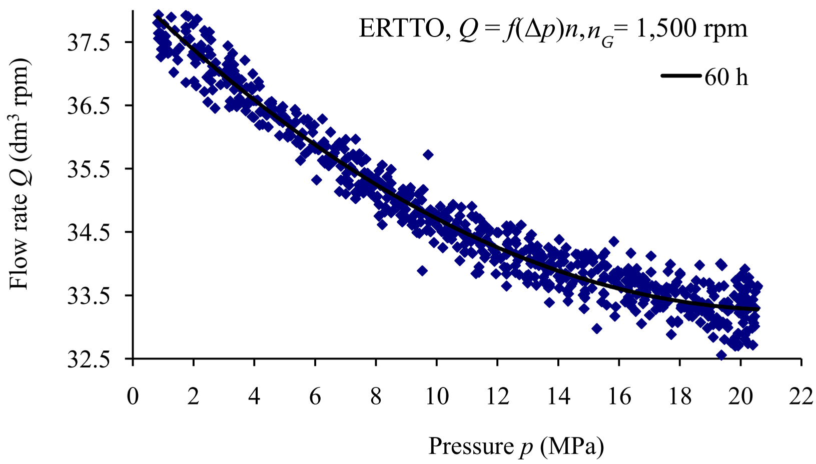

Fig. 6. Points measured during the measurements of the flow characteristics at n_G = 1,500 rpm

With application of the Ekouniverzal oil, ZTS 8011 tractor with hydrostatic pump type PZ 2–18 KS was in operation from 0 to 2,242 Mh; from output pressure of the hydrostatic pump of 16 MPa and nominal speed of hydrostatic pump of 2,200 rpm at 0 Mh, flow rate was measured as 22.80 dm^3rpm. After 2,242 Mh, flow rate was measured as 19.05 dm^3rpm. Durability of hydrostatic pump, type PZ 2–18 KS, is 2,000 Mh. On the basis of the measurements a decision was made that the hydrostatic pump has to be changed because the measured flow rate (19.05 dm^3rpm) was close to the minimal value 19 dm^3rpm (Tkáč, Škulec 2002; Tkáč et al. 2003).

RESULTS AND DISCUSION

The flow characteristics were measured during the durability test with the operating load (300 h) in intervals of 60 and 120 h. The characteristics were measured at the stated rotations of 800 rpm, 1,200 rpm and at nominal rotations of 1,500 rpm. Each measurement was repeated several times on the basis of calculation of the needed number of measurements.

Table 1. Technical data of the MOL Tractol ERTTO vegetable oil

Parameter	Value
Kinematic viscosity under 100°C (mm^2/s)	10,38
Kinematic viscosity under 40°C (mm^2/s)	47,89
Viscosity index *VI* (–)	213
Pour point (°C)	–39

In Fig. 6 the single measured points are depicted, with the flow characteristic of n_G = 1,500 rpm, after 60 h of the UD 25 hydrostatic pump durability test with the operating load in laboratory. For more transparency and facilitation of comparison of the achieved results, only the curves without the measured points will be further depicted. These curves, so called trend lines, were reached with a regression analysis using the polynomial model of the 3rd grade in the MS Excel program.

In Figs 7 and 9 the flow characteristics of the UD 25 hydrostatic pump are depicted; they were determined for the evaluation of the influence of the ERTTO (Environmentally responsible tractor transmission oil) hydraulic fluid on its durability during the operating load test. These figures also present flow characteristics of the new hydrogenerator at 0 cycles and after performing 10^6 cycles according to the norm STN 11 9287, which were achieved before the UD 25 hydrostatic pump durability test with the operating load.

Tkáč et al. (2008b) introduces description of testing equipment according to the norm STN 11 9287, which was implemented in the test.

Revolution of 1,500 rpm and pressure of 20 MPa at 0 Mh result in the flow rate of 34 dm^3rpm and of 33.15 dm^3rpm at 300 Mh. The flow rate decrease is 2.5%. Škulec et al. (2001), using the PZ 2–19 KS hydrostatic pump with Ekouniverzal oil, obtained a decrease of flow rate of 1.25% at revolution of 1,500 rpm and pressure of 16 MPa after 300 Mh. Test of hydrostatic pump, type UD 25, under operating conditions followed after laboratory test. The flow rate decrease of hydrostatic pump type PZ 2–19 KS (Škulec et al. 2001) was two times higher compared with the UD 25 hydrostatic pump that we tested.

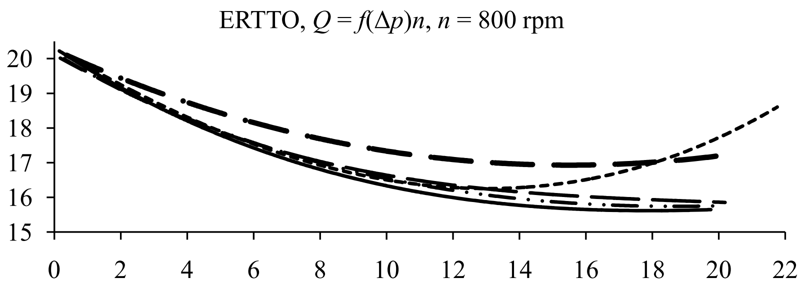

Fig. 7. Flow rate characteristic of the UD 25 hydrostatic pump at n = 800 rpm

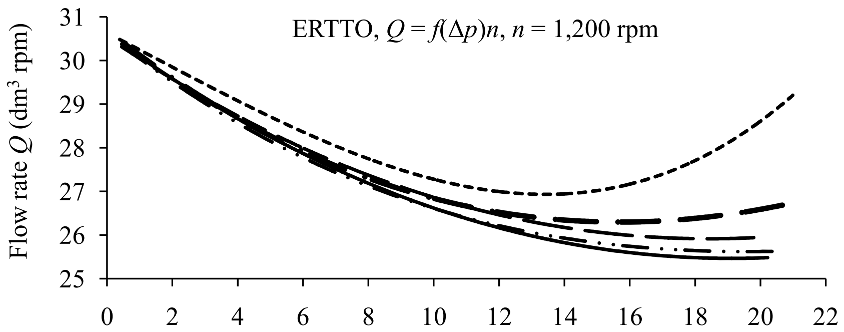

Fig. 8. Flow rate characteristic of the UD 25 hydrostatic pump at n = 1,200 rpm

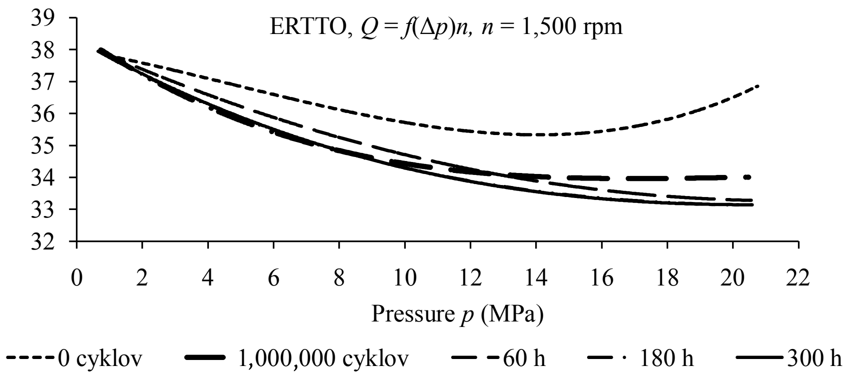

Fig. 9. Flow rate characteristic of the UD 25 hydrostatic pump at n = 1,500 rpm

CONCLUSION

The UD 25 tractor hydrostatic pump durability test with the operating load lasted 300 h in laboratory and followed after the test of the 10^6 cycles according to the norm STN 11 9287. The operating load test was performed with the MOL Tractol ERTTO biodegradable oil produced by the Slovnaft company, Inc. After 60, 180, and 300 h of performance the flow characteristics were measured at above-stated rotations (800, 1,200, 1,500 rpm) of the UD 25 hydrostatic pump.

On the basis of the achieved results we found out that the measured flow characteristics of the UD 25 hydrostatic pump have only a minimal decreasing tendency from 0 to 300 h. After the end of the durability test with the operating load in laboratory, the flow efficiency of the UD 25 hydrostatic pump decreased by 3.6%, which points at a good technical state, and is a proof of high quality of the used ecological hydraulic fluid on the basis of the ERTTO vegetable oil produced by the Slovnaft company, Inc.

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