THE EVALUATION OF THE TECHNICAL DURABLITY OF HYDROSTATIC PUMP UD 25 PER CLEAN LINESS MEASUREMENT OF HYDRAULIC FLUID

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Abstract

On the present, various methods are available for the evaluation of technical durability of hydrostatic pumps. These methods use a various physical principles. In this paper the design of test device and evaluation of test results is presented. The testing device was designed according to standard STN 11 9287 and verified its function. The observation of hydrostatic pump deterioration during the durability test was realized according to measurement of hydraulic fluid contamination per standard ISO 4406 - 1999. The contribution is replenished with several contamination measurements of hydraulic fluid, which are realized within projects of department KVaTZ. The results of measurement of fluid contamination were compared with measurement flow rate characteristics.

Key words*: cleanliness level; hydraulic fluids; hydrostatic pump; fluid contamination.*

1 Introduction

At the present time, hydrostatic systems are widely dispersed in the industry. It provides the various types of motions. The power transmission is realized by hydraulic fluid. Hydraulic fluid needs service and observation of operating parameters [4], [6]. One of its basis properties is cleanliness. Wearing particles present at the fluid report about wearing process. Hydraulic fluid has information on wearing process because it contains wearing particles. Therefore, it is needed to analyze particles in hydraulic fluid. The wearing process can be profitable observed by multi-parametrical diagnostic [2].

The contribution is centered on observation of wearing process of hydrostatic pump UD 25 during its lifetime test (STN 11 9287) according to cleanliness analyze of hydraulic fluid. Cleanliness analyze is verification of lifetime test results obtained by measurement of flow rate characteristic.

2 Material and Methods

2.1 The Designe of Test Device

The requirements on design of testing device are stated in standard (STN 11 9287). The testing device must be designed per parameters of tested hydrostatic pump too.

2.1.1 Požiadavky na priebeh cyklického tlakového namáhania podľa STN 11 9287

The demands according to the standard STN 11 9287 (1988) are stated as follows: “Technical durability be minimum 106 cycles under cyclic pressure loading from zero to the nominal pressure within frequency 0.5–1.25 Hz during velocity of pressure increasing 100–350 MPa/s and in nominal parameters. It this case decreasing of the volumetric efficiency may be maximum 20 percentages” (STN 11 9287 1988). The time characteristic of the cyclic pressure loading according to the standard STN 11 9287 (1988) is shown in Fig. 1.

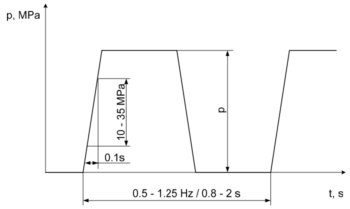

Fig. 1 Characteristic of cyclic pressure loading according to STN 11 9287.

The testing stand must be designed so that the running of the durability test corresponds to the standard STN 11 9287 (1988) Hydrostatic Gear Pumps and Hydromotors in which the dynamic loading of the hydrostatic pumps and motors (for the pressure *pn* = 16, 20 and 25 MPa art. 4), is realized by a selected characteristic of the working pressure or cyclic pressure loading.

2.1.2 Traktorový hydrogenerátor UD 25

The hydrostatic pump type UD 25 is one-direction hydraulic gear pump made by the company: Jihostroj Aero Technology and Hydraulics, Figure 4. This gear pump is equipped with the hydraulic balancing of axial clearance, which is done by sealing in the end face bearings. It finds the application in smaller and medium agriculture and construction machines. The hydrostatic pumps types UD are used in tractors Zetor, and in commercial car Tatra (Jihostroj a.s. 2007).

Baseline parameters of hydrostatic pump UD 25 are as follows:

- nominal pressure p_m = 20 MPa,
- nominal flow rate Q_m = 35,1 $dm^3 . min^{-1}$,
- nominal rotation speed n_m = 1500 min^{-1}.

2.2 Mineral oil MOL Traktol NH Ultra

MOL Traktol NH Ultra is universal tractor hydraulic and transmission oil with long time durability which is dedicated to lubrication of gearboxes, terminative schafts and hydraulic circuits. It can be used in agricultural machines and tractors. The technical information about hydraulic fluid MOL Traktol NH Ultra are listed in tab. 1.This oil is made by company Slovnaft a.s. [5].

2.3 Evaluation of fluid cleanliness

The fluid cleanliness will be evaluated per measurement of cleanliness level during the durability test of hydrostatic pump UD 25.

2.3.1 Definition of Cleanliness Levels per ISO 4406

The fluid contamination is evaluated according to cleanliness level. The cleanliness level can be determined by standards: ISO 4406 – 1999, SAE AS 4059 or NAS 1938.

The cleanliness level of hydraulic fluid per ISO 4406 is determined by counting number and size of particles in the fluid. Definition of cleanliness level per ISO 4406 is in tab. 2. The old ISO 4406 – 1987 defines the cleanliness level of particles lager than 5 µm and 15 µm according to two numbers X_1/X_2. X_1 defines number of particles lager than 5µm and X_2 defines number of particles lager than 15 µm (tab. 1). In 1999 both, the definition for particle counting and the definition of ISO code was changed. ISO 4406 – 1999 defines cleanliness level according to particle sizes larger than 4 µm, 6 µm and 14 µm [3].

Tab. 1 Definition of Cleanliness Levels per ISO 4406.

Počet častíc na 100 ml	Počet častíc na 1 ml	Trieda čistoty
1 – 2	0,01 – 0,02	1
2 – 4	0,02 – 0,04	2
4 – 8	0,04 – 0,08	3
8 – 16	0,08 – 0,16	4
*etc.	*etc.	*etc.

* The step to next cleanliness level means double or half the number particles.

2.3.2 Measurement of Cleanliness Level per ISO 4406 - 1999

CS 1000 states cleanliness level 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 device CS 1000 to hydraulic circuit are as follow:

- connection to suction or pressure pipe of circuit,
- flow rate of fluid must be from 30 ml . min^{-1} to 300 ml . min^{-1},
- 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.

3 Results and discussion

3.1 The Testing Stand for Realization of Laboratory Durability Tests

The scheme of the testing stand designed is illustrated in Fig. 4. This device allows to test the durability of gear pumps according to the standard STN 11 9287 (1988).

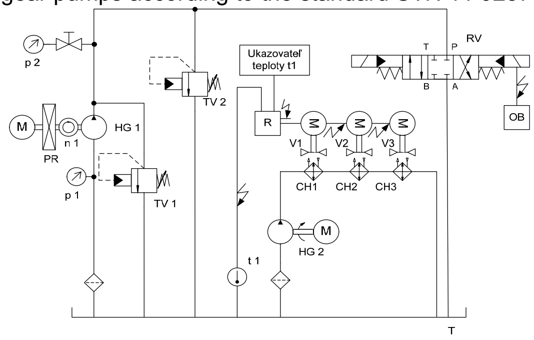

Fig. 2 Testing Stand for Realization of Laboratory Durability Test of Hydrostatic Pumps.

The hydrostatic pump UD 25 is marked in the scheme (Fig. 4) as HG 1. The hydrostatic pump HG 1 is driven by the electric motor M. The gear box PR is placed between the electric motor and the hydrostatic pump to enable the change of the hydrostatic pump rotation speed (the hydrostatic pump with the rotation speed *n* = 1500 min–1 does not require a gear box but is directly connected to the electric motor M.) The adjustment of the pressure gradient in the circuit is accomplished by the two stage sequence valve TV 2. The TV 1 is two-stage pressure relief valve which limits maximum pressure in the circuit by exhausting the fluid when the required pressure is reached. For the determination of the pressure gradient in the circuit, the pressure is measured by two pressure gauges of which one is placed in the suction pipe p 1 and the second one in the pressure pipe p 2.

The cyclic pressure loading is accomplished by the tree-position, four-port slide valve with the closed center RV which is operated electro-hydraulically. The three-position, four-port valve RV is connected to the output pipe of the hydrostatic pump HG 1. The change of the flow direction is realized by the position change of the valve RV. When this valve is in the mid-position, the fluid passes through the sequence valve TV 2. When the valve RV is in the left extreme position, the fluid passes into the tank. Thereby, the pressure loading conditions in the outlet of the hydrostatic pump HG 1 are changed.

3.2 The Verification of Pressure Loading of Testing Device

Fig. 5 shows the time-dependent characteristic of the cyclic pressure loading, which was measured by the testing stand, Fig. 4. The system function test of the testing stand was realized by the measurement of the characteristic mentioned above.

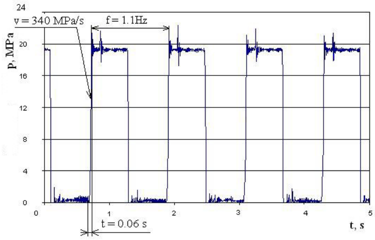

Fig. 3 Time-dependent Characteristic of the Cyclic Pressure Loading.

3.3 Measured Flow Rate Characteristics

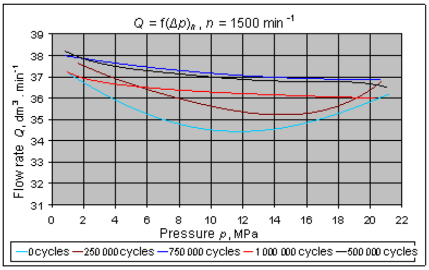

Fig. 4 The Flow Rate Characteristics Measured during the Lifetime Test of Hydrostatic Pump UD 25.

3.4 Results of cleanliness level measurement

Measurement of cleanliness level was realized in laboratory KVaTZ. The cleanliness level measurement is including of lifetime test of hydrostatic pumps. During the lifetime test of hydrostatic pump UD 25 was continually observed cleanliness level of hydraulic fluid by device CS 1000. Fluid ccontamination change during the lifetime test of hydrostatic pump is shown in Fig. 7.

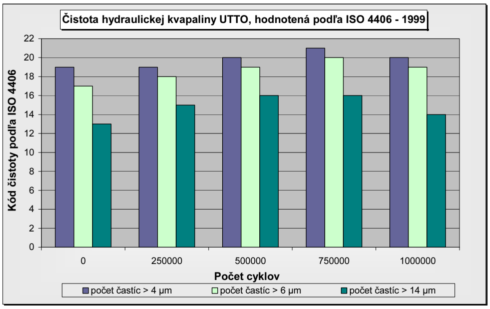

Fig. 5 The cleanliness level during the lifetime test of hydrostatic pump.

4 Conclusion

The aim of the presented paper is to design testing stand for durability tests of hydrostatic pumps. The demands for design of testing stands issue from parameters of hypothetic tested hydrostatic pumps and the loading process of hydrostatic pump during durability test (STN 11 9287).

The designed testing stands which are presented in this paper have technically solutions as follow: loading of hydrostatic pumps is realized by the tree-positions, four-port valve and sequence valve. Therefore, the characteristic of cyclic pressure loading is realized by tree-positions, four-port valve and sequence valve. The testing stand for the realization of the laboratory durability tests was designed so that the time characteristic of the cyclic pressure loading corresponds with the valid standard (Fig. 1).

The time characteristic of the cyclic pressure loading was measured by the test stand (Fig. 2) when its design was finalized. On the basis of comparison of the measured values (Fig. 3) (the frequency of the pressure increasing is f = 1.1 Hz, the velocity of the pressure increasing is v = 340 MPa . s^{-1}) with the interval of the values according to the standard (Fig. 1) (the frequency of the pressure increasing f = 0.5 Hz – 1.25 Hz, the velocity of the pressure increasing v = 100 MPa . s^{-1} – 350 MPa . s^{-1}), it is possible to state that the test stand is suitable for the durability test of the hydrostatic pump.

The verification of lifetime test results (Fig. 4) was realized by cleanliness level per ISO 4406 – 1999. Cleanliness level was measured by device CS 1000 during the lifetime test of hydrostatic pump UD 25 every 250 000 cycles. Measured cleanliness level is shown in column graph (Fig. 5). This graph shows particle distribution per cleanliness level.

During the lifetime test count of particles was increasing till 750 000 cycles because count of all particles larger than 14 µm, lager than 6 µm and lager than 4 µm was increasing. At the end of lifetime test (after 10^6 cycles) count of particles (lader than 4 µm) was decreased from value 21 (from 1 . 10^6 to 2 . 10^6 particles) to value 20 (from 0.5 . 10^6 to 1 . 10^6 particles). Therefore, after 750 000 cycles was decelerated particle production so running up of hydrostatic pump was finished. This fact is confirmed by flow rate characteristics (Fig. 4) too. These characteristics shows running up of hydrostatic pump to 750 000 cycles because to this time flow rate was increasing.

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Supported by the Ministry of Education of the Slovak Republic, Project VEGA №1/3483/06

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