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INNOVATIVE STAND FOR TESTING OF HYDRAULIC PUMPS AND MOTORS

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Abstract: *The article presents an innovative solution for developing of a stand on which both pumps and hydraulic motors are tested. The functional innovation of the stand is represented by the fact that the driving of the tested pump is made by the motor under tests, and the load on the shaft of the motor to be checked is provided by the checked pump.*

Keywords*: Stand, check, pump, motor*

1. Introduction

Hydrostatic pumps and motors are complex high-tech products used in a wide range of applications, of which we mention only their use in the production of stationary or mobile machinery and equipment.
For the verification of their technical characteristics and periodic certification or post-repair certification, these pieces of equipment must be checked according to specific methodologies on specialized test stands.
A modern testing system supposes the existence of computer resources in its structure. In addition, experimental testing systems must incorporate high precision sensors and transducers, as it is known that usually a transducer must be with an order of magnitude more precise than the degree of precision of the verified parameter. [1]

2. Checking of hydraulic pumps and motors

Checking the quality of hydraulic pumps and motors consists in performing the tests and checks as shown in Table 1.

Table 1

Ref. no.	Verifications, checks, tests	Pumps		Motors	
		TYPE tests	BATCH tests	TYPE tests	BATCH tests
1.	Running	x	x	x	x
2.	Exterior aspect	x	x	x	x
3.	Size of the main parts	x	-	x	-
4.	Materials of the main parts	x	-	x	-
5.	Connection and size dimensions	x	-	x	-
6.	Mass	x	-	x	-
7.	Displacement volume	x	x	x	x
8.	Maximum pressure	x	-	x	-
9.	Rated pressure	x	x	x	x
10.	Minimum (start) pressure	-	-	x	-

11.	Maximum speed	x	-	x	-
12.	Rated speed	x	x	x	x
13.	Minimum speed	x	-	x	-
14.	Internal flow losses	x	x	x	x
15.	Flow pulses	x	-	-	-
16.	Unevenness of speed	-	-	x	-
17.	External sealing	x	x	x	x
18.	Noise level	x	-	x	-
19.	Operation at extreme temperatures	x	-	x	-
20.	Running time (Endurance)	x	-	x	-

3. Test method for hydraulic pumps and motors

The method of testing hydraulic pumps and motors presented in this article concerns only the essential tests that are made for the qualitative assessment of these products.
For performing research testing, such as tests to verify dynamic operation, procedures can be completed with:
- measuring of physical parameters of mechanical nature (including hydraulic parameters) and converting them into electrical parameters;
- specialized IT (information technology) equipment for processing of signals from the testing process;
- test instructions adapted to the particular accuracy and special character of the tests.

3.1. Basic principles

Pumps and motors testing technology will include:
- hydraulic test diagram;
- structure of the hydraulic test diagram;
- instructions for the execution of the tests;
- indications regarding the expression of the verification results;
- other information necessary to perform the tests.

The running test was also included in the category of checks, although it is not a check in itself, but a functioning regime of a product that can be assimilated with a commissioning. [2]
By running it is intended to prepare the product to be able to operate at rated parameters by primary lubrication of the work surfaces in relative motion and their "fitting" so that it can take over maximum contact efforts.
Product life and the average time of proper functioning both depend on making correct running.
It is advisable to make the running on the test stand because it allows precise adjustment of functional parameters of the product and the working fluid.

3.2. Measurement of parameters

For the measurement of the parameters referred to above in point 2, in addition to conventional measuring instruments, there is also used modern equipment in which the measurement operations are carried out by means of transducers which allow the automation and introduction of information technology in the test process. In this way automatic setting of imposed parameters and automatic recording of the measured parameters are performed.
● Pressure measurement
The most common pressure transducers for equipping test stands for hydrostatic pumps and motors are:
- with elastic sensitive elements (curved tube, membrane, bellows, etc.);
- with piezoelectric elements.

● Flow measurement
Circulated flows are measured by direct or indirect methods:
- the transducers used for direct measurement are of the fixed volume measuring chamber type (graduated beaker) and are especially suited for pump discharge flows;
- the transducers used for indirect measurement of flow are: with hydraulic mill actuated by jet, with turbine, mass flow (Coriolis effect), with the reduction of flow section (with diaphragm, nozzle, Venturi tube), with swirled jet (Vortex type), with immersion device without articulation and without elastic reaction (rotameter), with articulated immersion device (with clapper).
● Speed measurement
The main types of speed transducers used in hydraulic systems are: direct or alternating current tohogenerators and speed transducers with photoelectric, inductive or magnetic elements.
● Power measurement
Determining the energy characteristics of hydrostatic pumps and motors requires measurements of torque moments and effective power.
Since the pump always works coupled with another motor machine, the power consumed on the pump shaft can be measured in two ways:
- directly, with electric power instruments and transducers in case of drive by electric motor and when is known the efficiency of the electric machine;
- indirectly, as in the case of the stand presented in this article, by measuring the torque by means of torsiometric couplings intercalated between the motor machine shaft and the pump shaft as well as the drive speed. [3]
● The other parameters involved in the test process - length, time, forces, temperature, density, viscosity, etc. - can be measured directly with the caliper, timer, etc. or indirectly with transducers of various types.

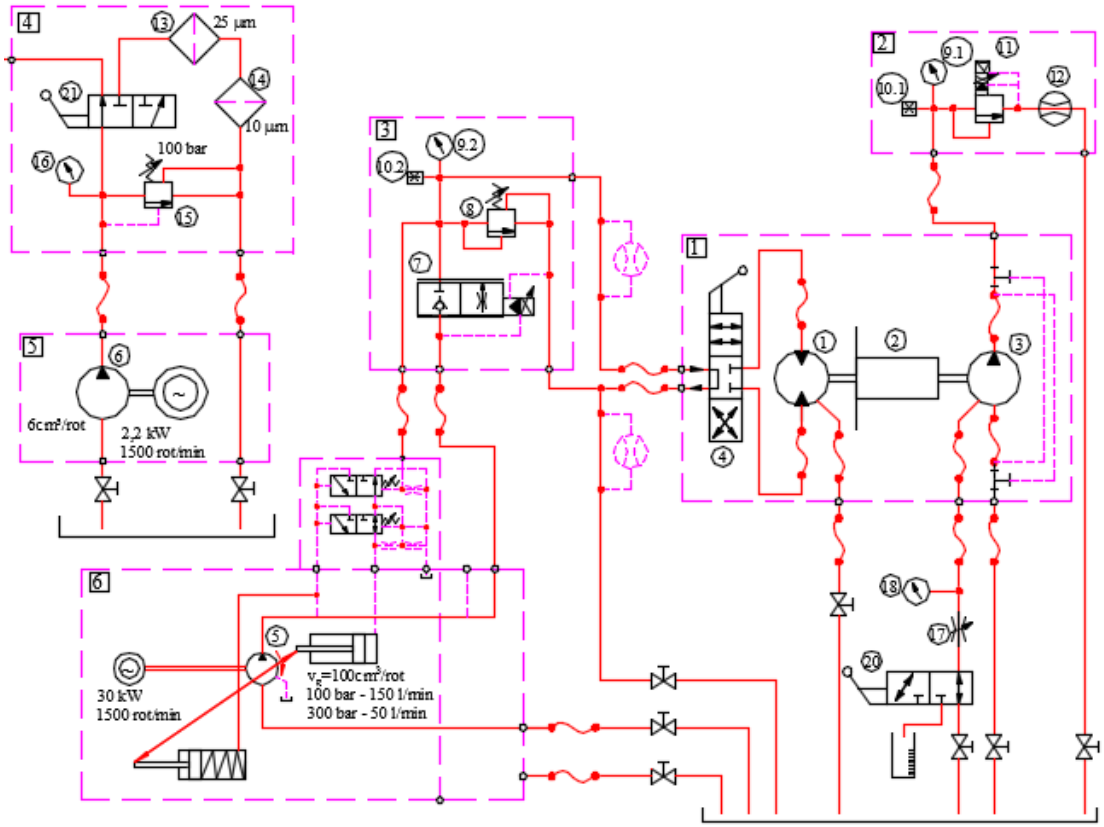
3.3. The test diagram and its structure

The test diagram of hydrostatic pumps and motors is shown in Fig. 1, and the structure of the diagram - in Table 2.

Table 2

Ref. no.	Furniture	Pcs.	Characteristics
1.	Hydraulic test / drive motor	1	125 cm^3 / rev; 320 bar;
2.	Speed and torque transducer	1	10 ... 3600 rev / min.;
3.	Test pump / load pump		
4.	4-way valve	1	rD 16; 320 bar;
5.	Electropump	1	30 kW; 1450 rev / min.; 100 cm^3 / rev; 320 bar; regulator DFLR
6.	Electropump for filtering and hydraulic controls	1	2.2 kW; 1450 rev / min; 6 cm^3 / rev; 100 bar;
7.	Proportional throttle	1	rD 16; 320 bar;
8.	Pressure valve	1	rD 16; 320 bar;
9.	Manometer Ø 100	2	400 bar; glycerine;
10.	Pressure transducer	1	400 bar; 4 – 20 mA;
11.	Proportional pressure valve	1	rD 16; 320 bar;
12.	Flow transducer	1	250 l / min.; 400 bar;
13.	Filter 25 µm	1	25 µm; 10 bar;
14.	Filter 10 µm	1	10 µm; 10 bar;

15.	Safety valve	1	rD 10; 100 bar;
16.	Manometer Ø 100	1	100 bar; glycerine;
17.	Throttle	1	rD 6; 10 bar;
18.	Manometer Ø 100	1	rD 6; glycerine;
19.	-		
20.	Three-way valve	1	rD 10; 10 bar;
21.	Three-way valve	1	rD 10; 100 bar



1. Pump drive and motor load device
2. Pressure adjustment subassembly
3. Flow control subassembly
4. Oil filter subassembly
5. Electropump for filtering and hydraulic controls
6. Electropump

Fig. 1. Stand for testing hydraulic pumps and motors. Hydraulic diagram

4. Structure of the test stand

The stand for testing pumps and hydraulic motors is made up of six subassemblies: pump drive and motor load device, pressure adjustment subassembly, flow adjustment subassembly, oil filter subassembly, stand electropump and oil filter and hydraulic controls electro-pump - see hydraulic diagram in figure 1.

4.1. Device for pump drive and motor load – fig. 1 /pos. 1.

It consists of a frame on which the hydraulic motor *1* is fixed to one end and the pump *3* at the other end. The motor shaft *1* rotates the pump shaft *3* by means of a coupling which encloses the torque and speed transducer *2*. The valve *4* inverts direction of rotation of the motor.

4.2. Pressure adjustment subassambly– fig. 1 /pos. 2.

The tested pump / load pump pressure *3* is measured with the manometer *9.1* and read with the pressure transducer *10.1*. The pump pressure is adjusted with the proportional valve *11* and the flow is measured with the flowmeter *12*.

4.3. Flow control subassembly – fig. 1 /pos. 3.

The speed of the hydraulic motor *1* is proportional to the oil flow with which it is powered by the stand electropump. Adjustment of this flow is done by means of proportional throttle *7*. The safety valve *8* limits the pressure on the discharge circuit of the pump. The pressure in the supply circuit of the hydraulic motor is indicated by the pressure gauge *9.2* and the pressure transducer *10.2*.

4.4. Oil filter subassembly – fig. 1 /pos. 4.

The subassembly consists of two cascade oil filters, a filter *13* with 25 μm and a filter *14* with 10 μm that provides filtering of the oil stand, a safety valve *15* which limits the pressure on this circuit at 100 bar, a manometer *16* and a valve *21* which switch the circuit on the filter function or hydraulic controls function.

4.5. Electropump for filtering and hydraulic controls – fig. 1 /pos. 5.

It ensures the operation of the hydraulic oil filter circuit in the test stand or the hydraulic controls if the pump or the motor to be tested has devices for variation of displacement volume with hydraulic control in its structure.

4.6. Electropump – fig. 1 /pos. 6.

The electropump *5* provides the required hydraulic power for the test stand. The variable flow required to achieve different test speeds is given by the variable speed pump *5* which has an L.S. pressure and flow control device.

5. Advantage of hydraulic actuation of the pump to be tested

At the test stand proposed in this article, the drive of the pump to be tested is achieved by a hydraulic motor. Figure 2 shows the graphs M - n for drive with hydraulic motor versus drive with electric motor and variable speed.

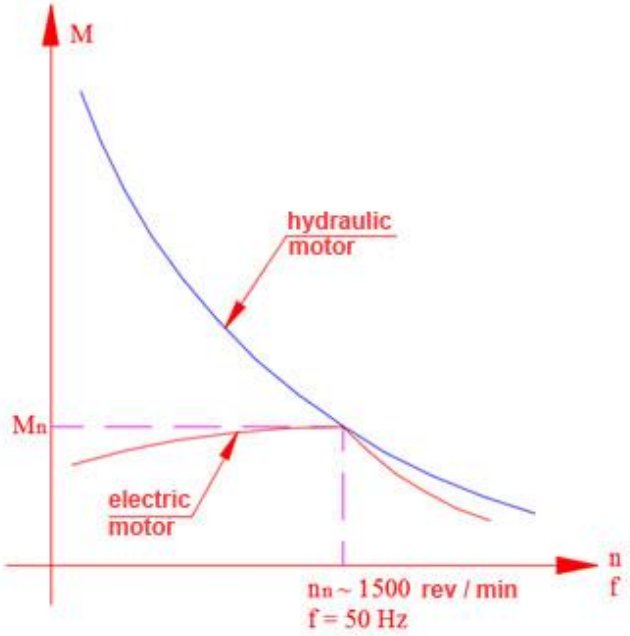


Fig. 2. Comparative chart M – n on electric and hydraulic drive

Hydraulic motor and variable speed drive is made on the constant power hyperbola P = n · M = ct. This means that if the test speed drops, the torque M = p · Vg increases, that is higher pressure tests and tests for higher capacity pumps can also be carried out. [4]
Electric drive with variable speed (frequency converter) lower than the rated one is made on the quasi-constant torque curve M = p · Vg $\sim ct$. This means that the values of the tested parameters: pressure and displacement volume cannot increase when the test speed decreases, and this is a disadvantage compared to the hydraulic drive.

6. Conclusions

The stand proposed in this article is an innovative solution in the field of hydraulic machines because:
● it allows the testing of both pumps and hydraulic motors on the same stand;
● it allows the hydraulic pumps to be tested at variable speed on the constant power drive hyperbola;
● it allows the carrying out of essential tests for the certification of the quality of hydraulic pumps and motors;
● it allows completion with special items for research purposes;
● it allows the realization of the controls, adjustments and registration of the tested parameters both in manual and automatic mode by implementing a control and monitoring system.

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