ISSN 1454 - 8003
Proceedings of 2018 International Conference on Hydraulics and Pneumatics - HERVEX
November 7-9, Băile Govora, Romania

TEST STAND WITH SPECIFIC SENSORS FOR DIGITAL HYDRAULIC CYLINDERS

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Abstract: *This article discusses the testing capabilities of the INOE 2000 - IHP digital hydraulic cylinders stand. It presents the functional scheme and the devices in the structure of the stand, as well as the working methods for the realization of the main tests that it can provide. Although the stand is for research, it can meet the general conditions of internal and international norms to determine the functional performance of hydraulic cylinders with the necessary adaptations for digital hydraulic cylinders.*

Keywords*: Test stand, digital hydraulic cylinders, tests, electronic control, data acquisition.*

1. Introduction

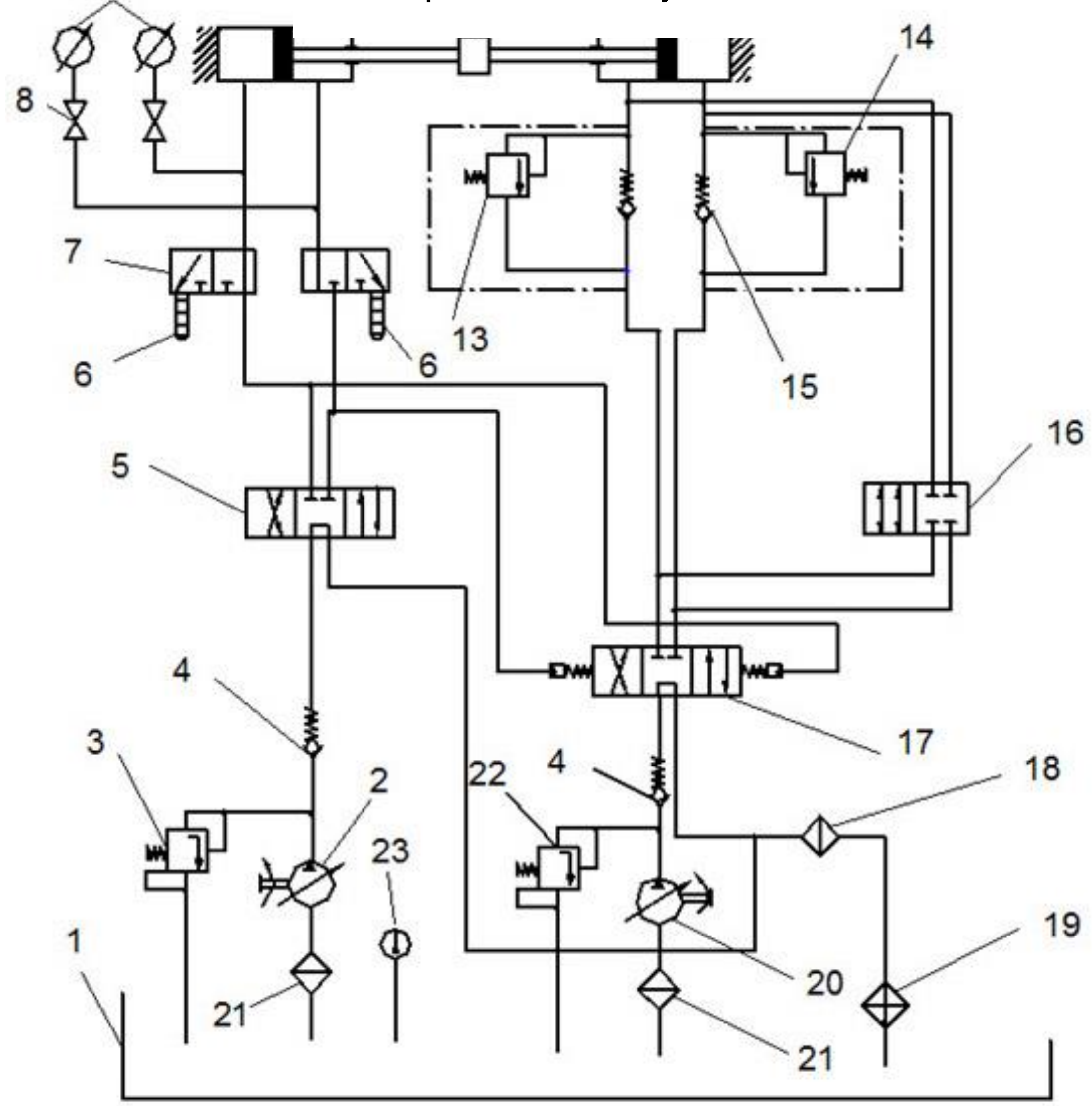
Hydraulic cylinders, also known as linear hydraulic motors or power cylinders, are designed to perform. They convert energy from hydrostatic energy into mechanical energy, characterized by two parameters, force and speed.
The use of linear hydraulic motors in hydraulic systems is a current practice and is often specific to each system designed to meet certain requirements. These engines have a wide spread due to the simplicity of construction and the possibility of achieving large and very large driving forces.

2.Tests and check methods for standardized hydraulic cylinders according to national norms of standardization

The checking of the minimum pressure for the uniform and shock-free movement of the piston and starting pressure is carried out when idling. The working chambers are filled with oil having the ambient temperature at which the test is carried out, the kinematic viscosity ν = 35 cSt. Connect a pressure oil source at one end. There is the lowest pressure at which the piston moves at minimum speed and the piston has a smooth and shock-free stroke throughout the stroke. Uniformity of the piston displacement speed is checked with a recorder.
The maximum admissible value of these pressures is specified in the technical documentation of the product.
The checking of the minimum, maximum piston speed, is performed at pressures ranging from 0.2-1.5 p_n but not more than 1.1 p_{max}; the displacement must be carried out under load, smoothly and without shocks throughout the stroke.
The checking of the pushing force and traction force is performed at pressures ranging from 0.2-1.5 p_n and at three speeds (minimum, middle, maximum) of the piston. The force is measured with dynamometers or force transducers with the class precision at least 1 per stroke interval corresponding to pressure and force stabilization. The mechanical resistance load is created with a load cylinder powered by a separate, low pressure hydraulic system and can be continuously varied in both directions by the adjustable pressure valve. The measurements are made for 5-8 values of pressure at three gears, within the mentioned ranges. The test speeds are obtained by varying the flow in the cylinder under test, with an adjustable flow pump.

2.1 Test scheme for standardized hydraulic cylinders

Example of a stand for cylinder tests



No	Fumiture	No	Furniture
1	Tank	10	Hydraulic cylinder to be tested
2 ; 20	Pumps	11	Force transducer
3 ; 22	Pressure relief valve	12	Load cylinder
4 ; 15	Check valve	13 ; 14	Counter-pressure valve
5;7;16;17	Directional valves	18 ; 21	Filters
6	Graduated vessels	19	Heat exchanger
8	Tap	23	Termometer
9	Manometers		

Fig. 1. Scheme recommended by STAS 8535-83

2.2 Digital hydraulic cylinders

In a conventional hydraulic cylinder, a fluid at a certain working pressure acts on a piston with a particular working area, resulting in a specific linear output force in accordance with the load to be displaced. If another output force is required, the fluid pressure must be changed because the piston area remains unchanged. From a hypothetical point of view, if the active area of the piston could be changed or only part of the area could be used, the fluid pressure could remain constant and the output force could vary. Unfortunately, there is no means by which the liquid can only act on a portion of a piston, since the pressure fluid acts equally on the entire area containing it.
Hydraulic digital technology is a solution to this new approach. In the case of digital hydraulic cylinders, it has been found that it is more cost-effective to vary the surface than to vary the pressure or flow for active cylinder control. By dividing the work area of a piston into annular zones with binary multiple sizes or according to other criteria, the selective pressurization of the annular chambers results in a cumulative output force that can be actively controlled in relation to the requirements of the system. The permutation of individually or cumulatively selectable combinations of zones / sections leads to a wide range of constant output flow / pressure outputs / speeds. Hydraulic digital drive is a new approach to linear drive. The basic principle is to divide the active surface of the cylinder. The result is an energy-efficient actuator that has a high maximum output but only needs a medium power output from the outside.

3. Stand for testing of digital hydraulic cylinders

The stand for testing the digital hydraulic cylinders (fig.2) consists of the equipment shown in the block diagram, fig. 3.

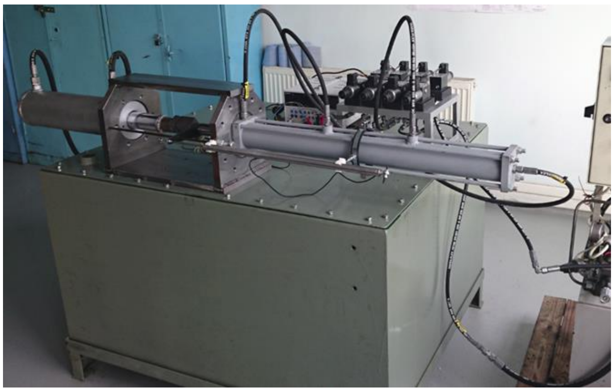


Fig. 2. Test stand

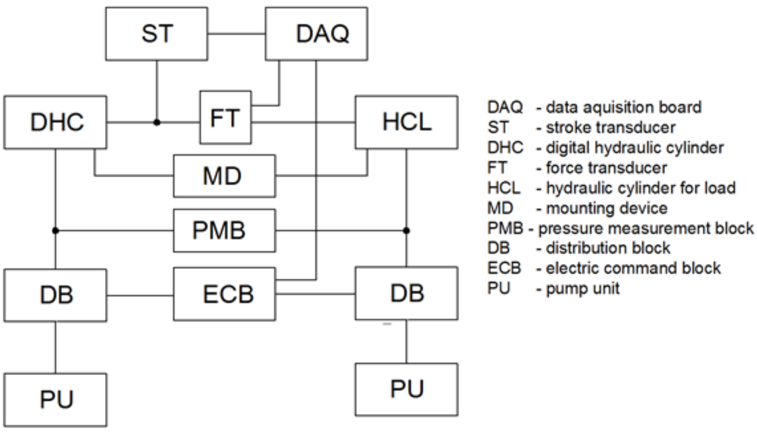


Fig. 3. Block diagram of test stand

ISSN 1454 - 8003
Proceedings of 2018 International Conference on Hydraulics and Pneumatics - HERVEX
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Figure 4 shows the hydraulic diagram of the digital hydraulic cylinder test stand.

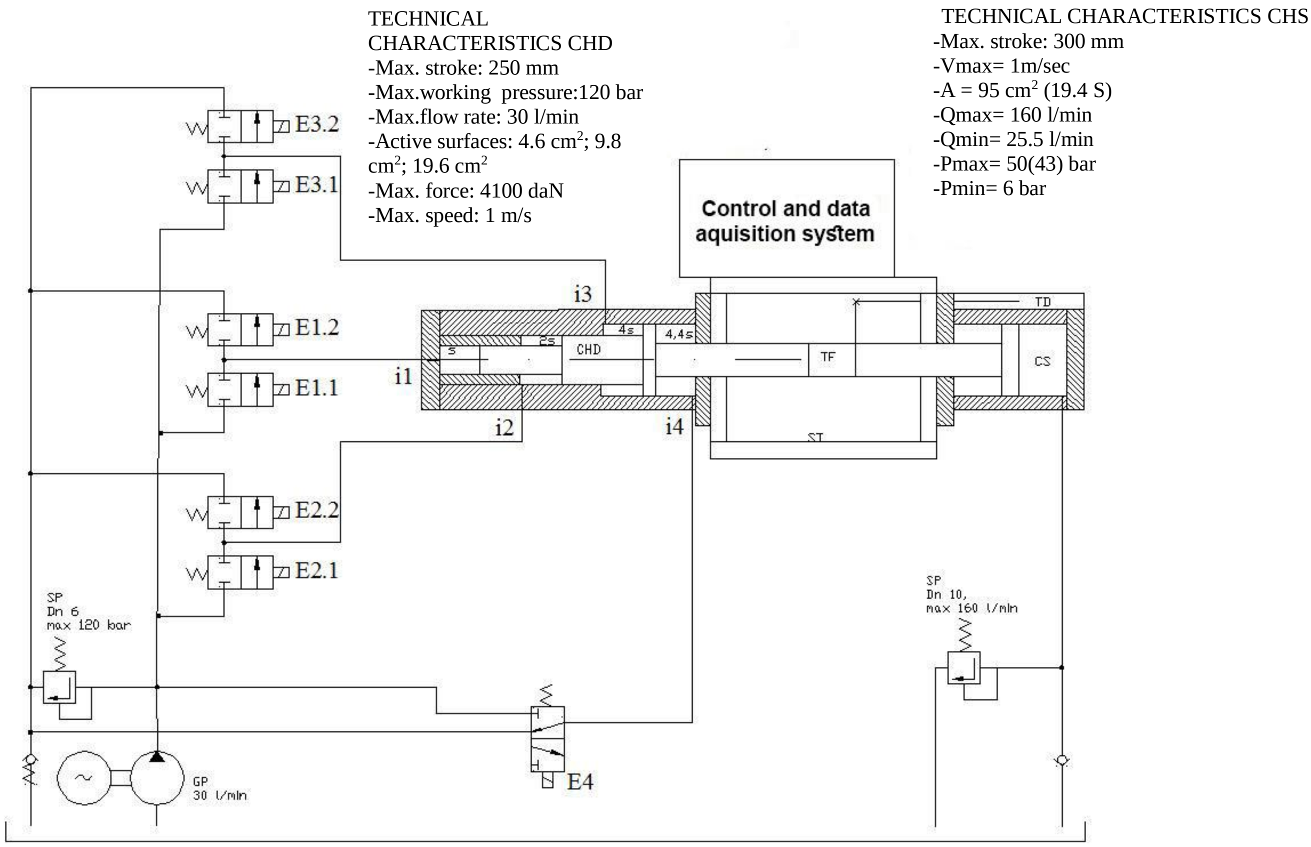

Fig. 4. Hydraulic diagram of the research stand for digital hydraulic cylinders

The stand includes a fixing device, fig. 5 on which the digital hydraulic cylinder for testing, fig.6 is mounted and the hydraulic cylinder for simulating the load, fig.7 at the rod of the digital hydraulic cylinder.

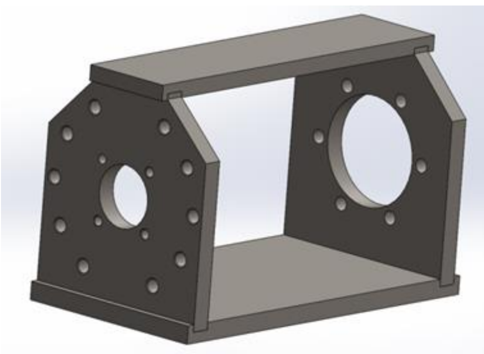

Fig. 5. Fixing device

Fig. 6. Digital hydraulic cylinder

Fig. 7. Load hydraulic cylinder

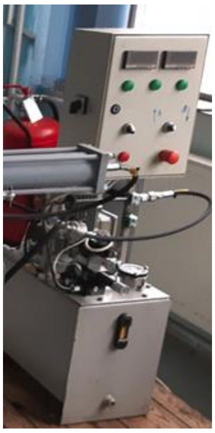

Fig. 8. Pumping station

The mounting device is fixed to the cover of an oil tank. Next to the stand are the pumping units (fig. 8) for the digital hydraulic cylinder and the load hydraulic cylinder.
The fixing device consists of a force transducer (TF) and a traction transducer (TD) (fig. 9), whose signals go to a given acquisition plate (fig. 10).

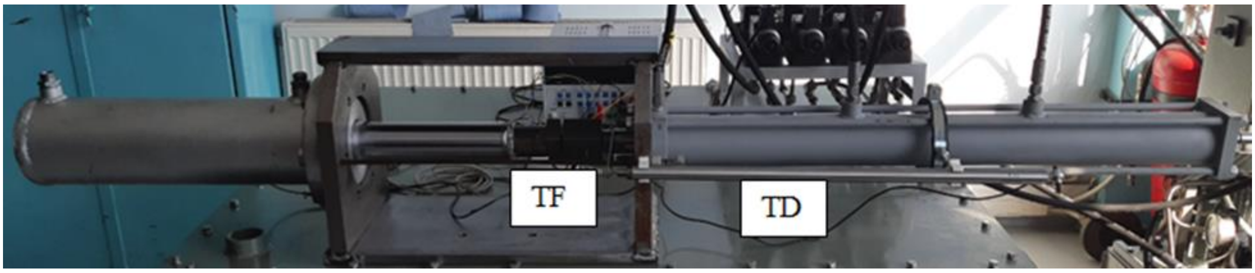

Fig. 9. Research device for digital hydraulic cylinders

Fig. 10. Data acquisition plate

The same data acquisition plate is used to give commands to the distribution block of the stand from fig.11 for different speed and force regimes of the digital hydraulic cylinder.

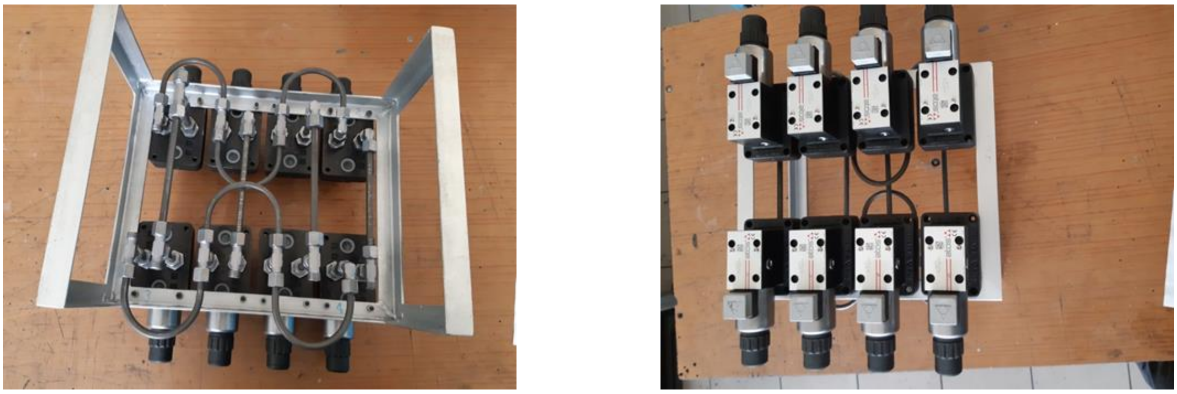

Fig. 11. Distribution block

A virtual instrument application (fig. 12) has implemented command logic for feeding the digital hydraulic cylinder chambers and the data acquisition system for the measured signals. The electric control block diagram (fig. 13) consists of 8 transistors which control the relays coils that feed the solenoids of the hydraulic directional control valves. The commands for the different working regimes of the hydraulic cylinder are given by the virtual instrument application via an electric control block (FIG. 14) which interfaces the digital outputs of the DAQ board with directional valves.

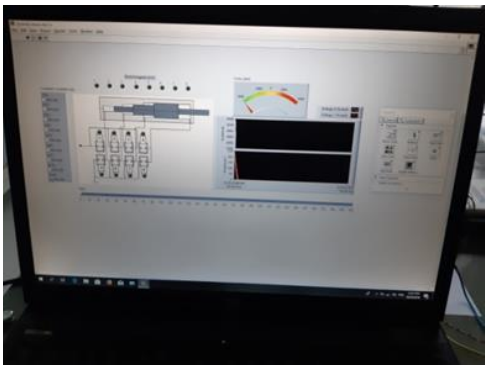

Fig. 12. Graphic interface of application

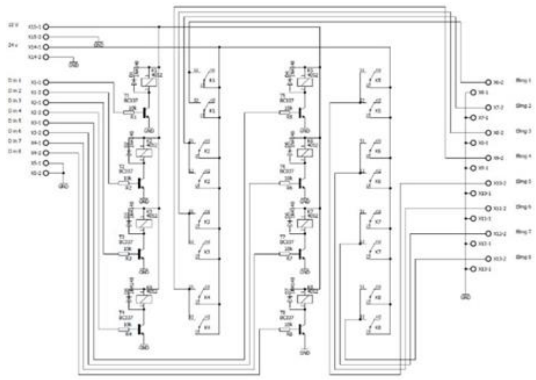

Fig. 13. Electronic diagram for electric command block

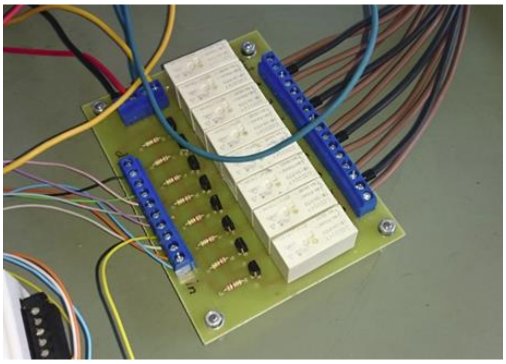

Fig. 14. Board with electric command block

The interface of the application is shown in fig.15. Figure 16 shows the schematic diagram for making the 7 advancement modes for the hydraulic cylinder rod and one for pulling out the rod.

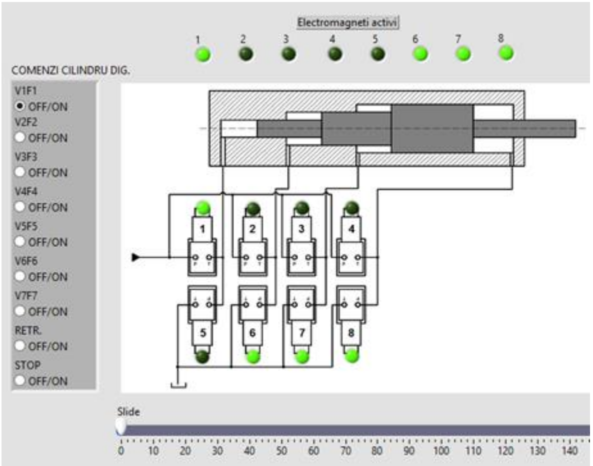

Fig. 15. Virtual instrument command interface

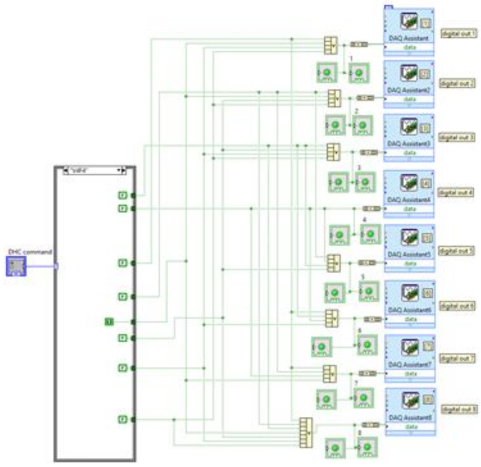

Fig. 16. Solenoids selection block in VI

4. Presentation of the main tests for achievement of the research papers

Table 1 shows the control cyclogram for plotting F = f (Ai) to p = ct and V = f (Ai) to q = ct. for digital hydraulic cylinders with three surfaces.
Where F corresponds to the force obtained with the lowest area at constant pressure and V corresponds to the speed achieved with constant flow for the smallest section, s represents the surface of the smallest piston, the control code represents the combination of active surfaces selected by the control of electromagnets E.

Table 1: Control cyclogram for three-dimensional digital cylinders

Command code	**Input commands to electromagnets**							**Cylinder with technologically optimized diameters**	
	E1.1	**E1.2**	**E2.1**	**E2.2**	**E3.1**	**E3.2**	**E4**	**Force**	**Speed**
0	0	0	0	0	0	0	0	0	0
1	1	0	0	1	0	1	0	1F	1V
2	0	1	1	0	0	1	0	3F	0.33V
3	0	1	0	1	1	0	0	3.975F	0.251V
4	1	0	1	0	0	1	0	4F	0.250V
5	1	0	0	1	1	0	0	4.975F	0.201V
6	0	1	1	0	1	0	0	6.975F	0.143V
7	1	0	1	0	1	0	0	7.975F	0.125V
Withdrawal	0	1	0	1	0	1	1	4.4F	0.227V

Where:

- The control code is the combination of electromagnets controlled for a pressure stage.

- S is the surface of the smallest piston.
- E1-E4 are electromagnets.
- F is the force with the smallest surface at the supply pressure.
- V is the speed obtained with the lowest section at the supply flow.

Expected results for rod advance:

- For variance of force: F = f (Ai)
- F = PxS

Where:

- F- The resulting force with the smallest surface
- P-Pressure (constant)
- S-Surface (variable)

4.1 Hydraulic cylinders specific tests

The checking of the minimum pressure for the uniform and shock-free movement of the piston and the starting pressure for the three-dimensional digital hydraulic cylinder is performed in idle. The working chambers are filled with oil having the ambient temperature at which the test is carried out, the kinematic viscosity v = 35 cSt. Connect all surfaces of the cylinder to a pressure oil source according to the test scheme. The lowest pressure at which the piston moves at the minimum speed and for which the piston has a smooth and shock-free stroke for each surface of the multi-surface cylinder and all the summed surfaces is recorded over the entire length of the stroke. For the three-dimensional cylinder, commands corresponding to command code 1,2,4 and 7 are executed in the control cyclogram. Uniformity of the piston displacement speed is checked with a recorder. The measurement result is added to the test sheet.

The checking of the pushing force is made at constant pressure by selecting the combinations of sections of the multi-surface digital cylinder over the entire length of the stroke. Force is measured with force transducers with precision class at least 1 per stroke interval corresponding to pressure and force stabilization. The load of strength-type is created with a hydraulic cylinder powered by a separate, low-pressure hydraulic system and can be continuously varied through the adjustable pressure valve. The measurement is made to determine the force variation according to the combination of selected surfaces, F = f (Ai) at constant pressure. Check controls are made in accordance with the control cyclogram, successive for all combinations during the rod forward stroke. The measurement result is added to the test sheet and compared to the expected result.

The checking of the piston speed is made at constant flow rate; the displacement must be carried out under load, smoothly and without shocks throughout the stroke. The check is made for each surface combination of the multi-surface cylinder and all the summed surfaces, during the rod forward stroke. The measurement is made to determine the velocity variation according to the combination of selected surfaces, V = f (Ai) at constant flow. Check controls are made according to the control cyclogram. The measurement result is added to the test sheet and compared to the expected result.

5. The results obtained in the research activity

At the test, the commands to the distribution block were applied according to the control cyclogram in table 1 and the force graph corresponding to the combination of active surfaces fed with 120 bar pressure was obtained.

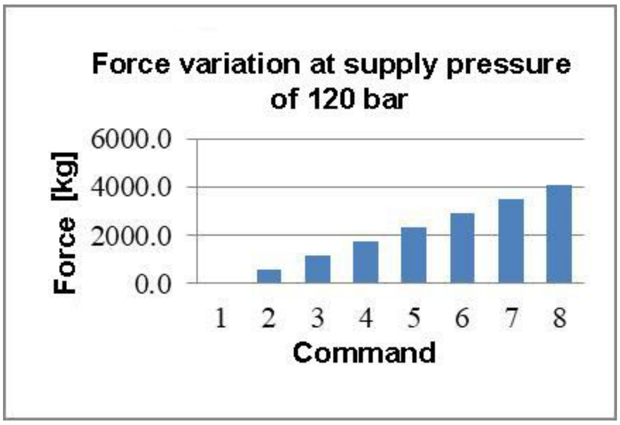

Fig. 15. Example of force variation for the supply pressure of 120 bar to the cylinder with three binary multiplied surfaces

Also under the same test conditions (according to table 1), the graph of the variation of the displacement speed of the cylinder rod was obtained at a constant supply flow of 30 l / min.

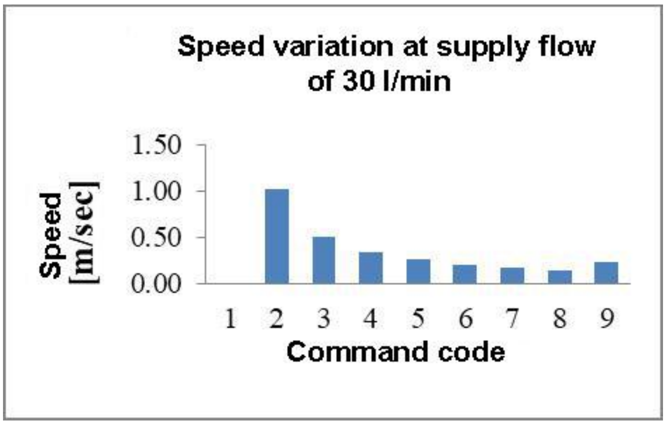

Fig. 16. Example of speed variation for supply flow of 30 l/min in the cylinder with three binary multiplied surfaces

6. Conclusions

The research stand for digital hydraulic cylinders is the first achievement in the field of Digital Hydraulics from the institute and from the country and enables full testing for normal working regime, to determine key parameters and dynamic regime for tracing the response diagram to step signal.
The tests results of the digital cylinder behavior in dynamic regime of response to step signal will be used to formulate conclusions on the performance of the tested digital cylinder and to formulate proposals for new research directions in the studied field.

Acknowledgment

This paper has been developed in INOE 2000-IHP, supported by a grant of the Romanian Ministry of Research and Innovation, under the National Research Programme NUCLEU, project title: “Advanced research in the field of physical processes and techniques specific and complementary to the systems which emit, modulate, transmit and receive optical radiation/OPTRONICA V”, project code PN18-28, financial agreement no. 33N/16.03.2018.

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