Testing Means of Piston –Type Seals

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Abstract: *To improve energy efficiency of hydraulic drive systems, an important direction of action was the increase in energy efficiency of each component, in the direction of decreasing hydraulic flow and pressure losses, energy losses in general, and respectively increasing outputs and their lifespan.*
One of the most important components of hydraulic applications is the hydraulic drive motors, which convert hydrostatic energy into mechanical energy.
Tribological research on linear hydraulic motors, also known as "hydraulic cylinders", aims at assessing total energy losses during operation and increasing their lifespan.
These total energy losses include viscous friction losses occurring at fluid flow, frictional losses occurring in rod seals (between the rod and bush), frictional losses occurring between the piston seals and the liner, as well as energy losses through dry friction inside the guides of the rod and piston. An important role in increasing the life of hydraulic cylinders is played by the durability of sealing systems, which are the first to remove hydraulic cylinders from operation.
In order to optimize the total energy losses in the operation of the hydraulic cylinders and to increase their lifetime (by increasing the sealing lifetime), two innovative sealing elements for the piston and rod were developed at IHP Bucharest, tested by using the means presented in this article.

Keywords: *Piston-type seals, hydraulic cylinders, testing stand*

1. Introduction

The methodology and the device developed during the stage *Developing new sealing elements by tribological research on the sealing systems in the hydraulic equipment* serve the economic agents specialized in the manufacture of sealing elements for hydraulic equipment, hydraulic cylinder manufacturers and companies that have reconditioning in their activity profile, enabling them to test performance and lifetime of sealing elements in an accelerated mode.
This methodology establishes the way of performing hydrostatic sealing tests, tests of endurance and measurement of internal fluid losses for piston seals in the structure of linear hydraulic motors (cylinders) used in the field of hydraulic drives.

2. Testing methods applied in laboratory

At present, the tests are carried out on a hydraulic cylinder, with piston-mounted test sealing elements actuated by an antagonist force cylinder. This method has major drawbacks: very high energy consumption, excessive oil heating, large stand size. The device developed removes the mentioned disadvantages by the fact that:
- it uses a small volume of oil;
- the (constant) test pressure is only exerted on the active surfaces of the sealing elements [1];
- testing of seals is done at pulsating pressure generated by an electric pump - directional control valve system, which has low power consumption, according to the test diagram shown below.
The two sleeve-type sealing elements for the piston will work in dynamic mode (alternative linear movement) at a maximum pressure of 160 bar.
Benefits:
- energy savings;
- small oil volume being used;
- the (constant) test pressure is only exerted on the active surfaces of the sealing elements;
- testing of seals is done at pulsating pressure;
- the possibility to simulate the tests in conditions similar to the operational ones [2] .

Technical specifications:
- Type of sealing element .... sleeve;
- Working pressure on the sleeve .... 160 bar;
- Linear displacement velocity of the sleeve .... 0.1 m / s;
- The outer diameter of the sleeve with its own test box .... from 25 to 125 mm;
- Working environment .... H46 A hydraulic oil;
- Stroke……………………………………. .... 145 mm.

2. 1 Hydraulic schematic diagram

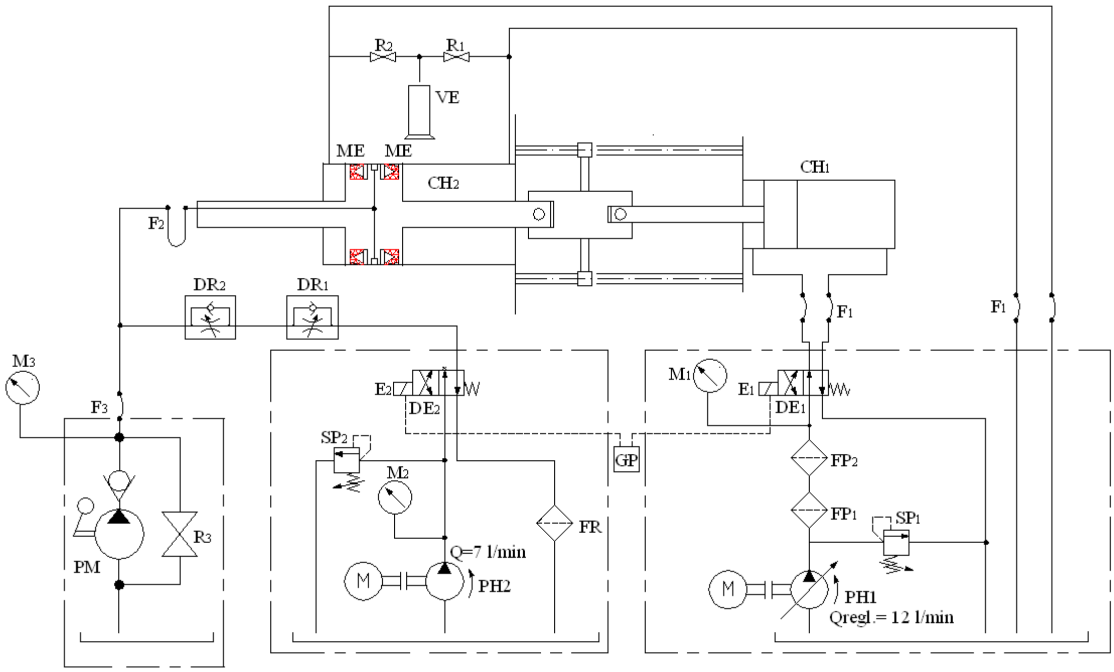

Fig. 1. Hydraulic schematic diagram of the test stand designed for piston-type seals

The device for testing hydraulic piston seals [3], Figure 2, is composed of a frame made as a welded structure (1), on which a special design hydraulic cylinder is mounted, consisting of the caps (2) and (6), which together with the liner (5) form the chamber in which the piston (3) and a standard brake drive cylinder (8) move. The rods of the two hydraulic cylinders are coupled by a translation coupler (7) which slides on two horizontal columns (9) by means of the guides (10).
The hydraulic cylinder mounted on the right wall of the frame is purchased from the series production of Wipro Infrastructure Engineering SA - Râmnicu.Vâlcea. Fixing is done by using a front flange, and there occurs piston brake at the end of the stroke. This cylinder is designed to overcome friction forces that occur when moving the rods, pistons and guides.
The hydrostatic test on the two identical seals mounted on the piston is carried out by using the PM hand pump, which sends the pressurized oil in the circular duct of the seals through the longitudinal slot in the testing box rod; oil loss behind the seals is collected in graduated vessels, from the fittings of the testing box caps (2) and (6).
For the endurance (lifetime) test the piston 3 is alternately displaced in the liner (5), by means of the two rods, by the cylinder 8.
During a stroke, the annular chamber pressure has a maximum value of 160 bar, and on the reverse stroke pressure has a minimum value of about 6-8 bar, which is generated by the hydraulic resistors on the return circuit of the hydraulic test unit. In this way, the sealing element functioning is reproduced in the actual working conditions of the hydraulic cylinders. Following a couple of stroke mileages, the piston on which the gaskets are mounted is stopped and the fluid losses at the holes in the caps are measured. The amount of lost fluid, correlated with the number of kilometres of stroke, define the degree of wear of the gasket.

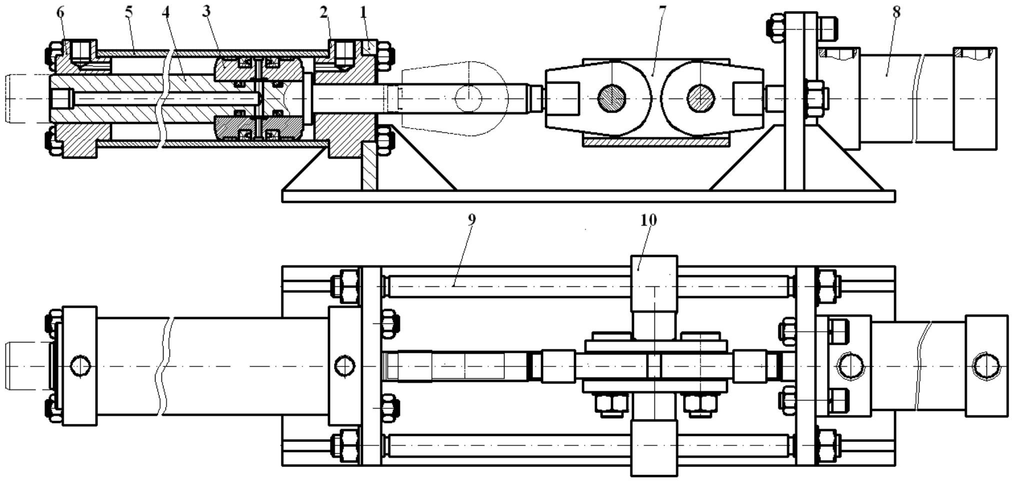

Fig. 2. The main parts of the device
1-frame, 2,6-caps, 3-piston, 4-rod, 5-liner, 7-coupling,
8-standard hydraulic cylinder, 9- guide columns, 10-guide

The piston of the special cylinder, fig. 3, is equipped with the sealing elements to be tested, in this case, sleeves for ϕ 63 -code PA-63 x 48 x 9.5 hydraulic cylinders.

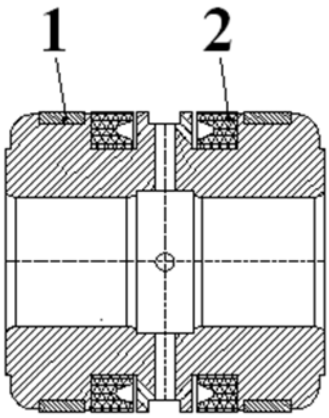

Fig. 3. Special construction of the piston
1-guide ring, 2-piston sleeve


a

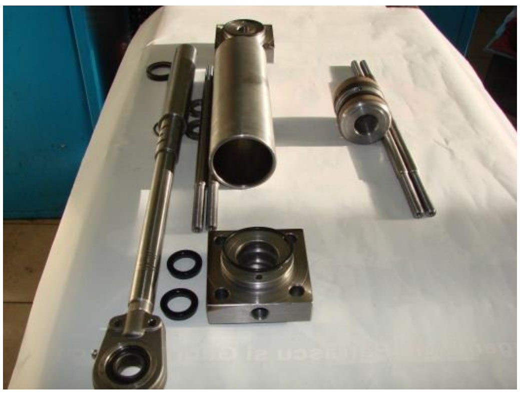
b

Fig. 4. Component of the cylinder for testing piston-type sealing elements


a


b

Fig. 5. Special construction piston on which the piston- type seals are mounted

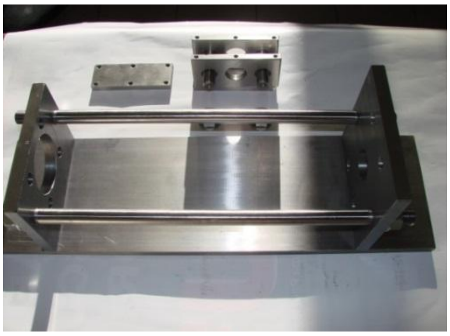

Fig. 6. Frame of the testing device for piston-type sealing elements

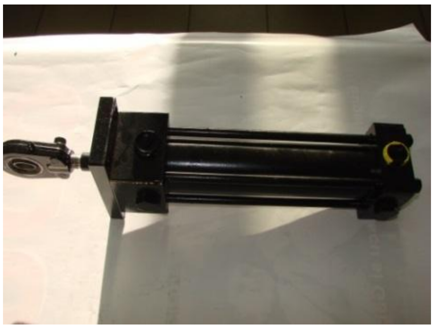

Fig. 7. Standard hydraulic cylinder D_p 50-code CH 16U050/22-145.4.HM3.0

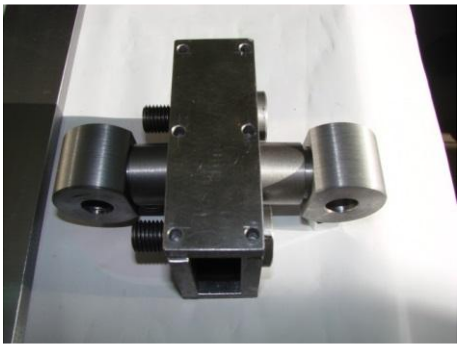

Fig. 8. Coupling for connecting the rods of the cylinders in the structure of the device

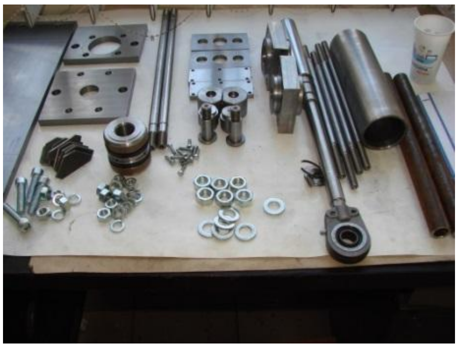

Fig. 9. Components of the device for testing of piston-type sealing elements, before assembly

Fig. 10. Device for testing piston-type seals, assembled

Testing of the sealing elements has been conducted on a stand from the Laboratory of servo-technique at IHP – Bucharest; the test stand has been adjusted in order to meet the requirements of the diagram in fig. 1.

2.2 Stand for testing piston seals of hydraulic cylinders

The stand, fig. 11, generates and distributes the working fluid at the parameters mentioned in the technical sheet to the drive cylinder, respectively to the seal testing box in the structure of the testing device.

Fig. 11. Stand for testing piston seals of hydraulic cylinders

The pressure at which the piston-type seal elements are tested by using the device is the working pressure at which they operate in the linear hydraulic motors for which they have been designed, that is 160 bar.
The speed of movement of the sealing element is adjusted according to its construction and the materials used. The travel speed of the sleeve under tests is in the range from 0.01 to 0.5 m / s.
The PH1 pump provides the hydraulic parameters (flow rate, set at 5 ... 6 l / min, and pressure, set to 100 bar through the SP1 valve) which are required for CH1 hydraulic cylinder to operate. The PH2 pump provides the hydraulic parameters required to test the two sealing sleeves of the device (fixed flow rate of 7 l/min, pressure set at 160 bar through the SP2 valve).
To ensure the displacement of the pistons of the hydraulic cylinders in the structure of the device, the electromagnets E1 and E2 are simultaneously operated by engaging them to perform the active stroke, when in the areas of the test sleeves the pressure of 160 bar is created, or by disengaging them to perform the retraction stroke of the pistons, when the pressure in the areas of the sleeves decreases to 6 ... 8 bar. The R1, R2, R3 tap valves are closed, and the DR1 and DR2 throttles are completely open. The operation is repeated 8 ... 10 times.
Checking of safety and external sealing - The hydrostatic pressure of 240 ... 245 bar is generated by the PM manual pump. Displaying of its value is done on the M3 pressure gauge. The pressure maintenance time is 3 minutes, while the R3 valve and the DR1 throttle are closed, and the PH1 and PH2 pumps stopped.
The test piston displacement speed is achieved by adjusting the flow rate of the PH1 pump and timing the stroke duration, so that to obtain a speed of 0.1 m / s.
The fluid loss check [Δq] is done according to the diagram. The PH1 pump is adjusted so that the CH2 cylinder moves at a speed of 0.1 m / s. The PH2 fixed flow pump achieves the pressure of 160 bar required to test the two sleeves, adjusted by the SP2 valve. The E1 and E2 electromagnets are simultaneously engaged, and then disengaged. Duration of engagement and disengagement times are equal, with a value of 2s. The operation is carried out by the GP program

generator, which performs operation of electromagnets and adjusts the 2-second engagement duration. During the alternate displacement of the CH1 drive cylinder, the rod of the CH2 cylinder also moves; in the two chambers adjacent to the piston on which the sleeves are mounted mineral oil is sucked in and discharged. During this period, a pulsating pressure of 6 ... 160 bar is installed in the annular chamber of the piston; its impulse has a slope of increase and decrease adjustable by means of the DR1 and DR2 throttles. Following approx. 35,000 double strokes (5 km) - duration 2h 30sec, the program generator and the PH1 pump are stopped. The E2 is actuated from button; the R1 and R2 tap valves open and close successively, and after the oil on the pipes drains, the flow losses corresponding to each sleeve are collected. The collecting time is 10 minutes.

3. Conclusions

- Methodology and testing device are used for an accelerated testing of piston-type seals;
- Currently, tests on these seals are carried out on a hydraulic cylinder driven by an antagonist force cylinder, with piston-mounted sealing elements to be tested; in this case, energy consumption is very high, excessive oil heating occurs, and the test stand has a large gauge;
- The benefits of the present methodology and test device result from the following considerations:
• use of a small oil volume;
• the (constant) test pressure is exerted only on the active surfaces of the sealing elements;
• testing of the seals is done at pulsating pressure, achieved by a low flow rate and low power consumption electro-pump – directional control valve system, according to the test scheme presented;
• the sleeve-type sealing elements for the piston will work in dynamic mode (alternative linear motion) at the actual working pressure of the hydraulic cylinder that they will fit.

Acknowledgments

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