

DIAGNOSTICS OF HYDRAULIC CYLINDERS OF FREIGHT CARS

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Abstract: The paper gives a description of the way to check functionality as well as diagnostics and repair of cylinder parts. The aim of the work is to show one hydraulic part (hydraulic cylinder) through a complete observation from the way it functions and checking the correctness to a complete check of the parts and a proposal with a description of how to eliminate the defects.

Key words: hydraulic cylinder, failure, diagnostics, piston, connecting rod.

1. INTRODUCTION

In the majority of cases, cylinders are directly connected to the device or machine, which means that they are exposed both to the effects of external factors (temperature, moisture, dust, vibrations, mechanical shocks, extreme loads, etc.), and to the effects that are manifested as a consequence of the process that takes place in the hydraulic circuit itself (pressure, friction between moving elements, temperature of the working fluid, hydraulic shocks, currents, etc.). When it is known that cylinders are integral elements of machines and devices, and that their dismantling requires long-term and complex activities, and that the machine, device or the entire production line is not in production function, additional elements are acquired that determine the complexity and responsibility of the overhaul process and examination of the same.

2. MANIFESTATION OF CYLINDER DAMAGE

Any change in the operation of the cylinders gives us information that there has been damage or failure of the cylinder, except in cases of insufficient fluid flow. These changes are manifested as the following damage or failure of the cylinder:

- reduced piston movement speed,
- reduced piston force,
- the piston is at rest, even though the required pressure has been reached in the piston chamber,
- the piston cannot be brought to the end position,
- during movement, the piston realizes an oscillatory movement,
- noise is produced when the piston is brought to the last possible position

The mentioned changes manifested in the operation of the cylinder are conditioned by the most frequent failures given in Table 1.

Table 1- The most common cancellations

Cancellation	Reason for termination
Damaged piston rod seals	- particles stick to the surface of the

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	connecting rod - axial forces act on the connecting rod - the connecting rod surface is deformed - the axes of the cylinder and connecting rod do not match - the sealing material is not suitable - oil reduces the hardness and/or increases the swelling of the sealant material - the cylinder fastening system is not suitable
The piston seal kit is damaged	- there are solid particles in the oil - the sealing material is not suitable - oil reduces the hardness and/or increases the swelling of the sealant material - the axes of the cylinder and the piston do not coincide - during the stop of the piston, there is a sudden increase or decrease in pressure in the piston and piston rod side - the gasket was not replaced correctly
The connecting rod surface is damaged	- solid (abrasive) particles adhere to the outer surface of the connecting rod - the hardness of the built-in sealants is high - the hardness of the connecting rod surface is not appropriate, the material of the connecting rod does not correspond to the working conditions in an aggressive atmosphere
The piston rod is deformed	- the connecting rod is not well designed for bending - the connecting rod is overloaded with radial force - the cylinder attachment system is not suitable - the connecting rod is overloaded with axial force - the axis of the cylinder and the connecting rod do not match
Traces of damage to the inner surface of the cylinder in the form of furrows and grooves	- there are solid particles in the oil - the hardness of the sealant is high
The cross-section of the inner surface of the cylinder has become elliptical due to the wear of the surface on which the piston rests	- the hardness of the cylinder surfaces is not sufficient - the hardness of the sealant material is high - a radial force acts on the piston rod - the damage is the result of long-term operation of the cylinder
Occurrence of a crack or breakage of the	- the clip stops

front or back cover	by bringing it to the extreme right or left position without damping, so impact and material fatigue occur - occurrence of hydraulic shocks
Piston movement speed is less than required	- the piston seal has worn out - there was wear of the inner surface of the cylinder evenly over the entire section, scratches, on the lower contact surface
The piston force is less than required	- the piston seal has worn out - there was wear on the inner surface of the cylinder
The piston moves at an uneven speed	- the hardness of the sealant is high, so there was an increase in the friction force (characteristic for low movement speeds) - there is air in the oil
The piston does not reach the end position	- mechanical damage to the sealant - air plugs formed in the cylinder chambers

The condition of the cylinder can be checked with a degree of accuracy without disassembly from the hydraulic system. Piston movement speed and piston force are tested. The test of the piston movement speed is performed without load and with load. The time required for the working stroke of the piston is measured, and it should be approximately the same value in both cases.

In parallel with the test of the speed of the piston movement, a force test is performed, so that at the set and achieved pressure value, the external load must be overcome with the required speed of the piston movement.

On the test bench, the force of the piston, pressure retention in the piston and connecting rod side, speed of movement of the piston under load and the flow of oil from the pressure side to the return side are tested [2].

3. CYLINDER FUNCTIONALITY CHECK

Testing and diagnosis of the cylinder is performed on a special test table.

Testing the functionality of the cylinder begins with 30% of the nominal load in order to achieve the optimal temperature of the working fluid and adjust the speed of the piston rod. After that, five cycles are performed with 100% of the nominal load and five cycles with 150% of the nominal load. One cycle means the movement of the piston from one end position to another and back to the initial position. After the completed cycles, a visual inspection of the condition of the connecting rod is performed.

[2]

The cylinder is satisfactory in terms of functionality if the pressure is constant during the full stroke of the piston. No deformations must occur on the piston rod.

3.1. Piston rod sealing efficiency

Piston rod sealing is measured by the amount of liquid Q (cm^3) that leaks out of the cylinder chamber past the piston rod seals at nominal load (100%) and at a certain number of cylinder strokes.

The degree of wetting is defined as a criterion. Residual wetting refers to the surface of the working space of the tested sample, that is, the amount of oil that leaks past the connecting rod from the cylinder chamber. The permitted residual oil moisture per cylinder is 0.1 mg/cm .

3.2. Piston sealing efficiency

The sealing efficiency of the piston is checked by measuring the amount of liquid that leaks out at maximum pressure in a period of 30 minutes. Before checking the sealing of the piston, it is necessary to equalize the temperature of the working fluid in the chambers. The amount of oil that leaks past the piston seals is measured on the test table.

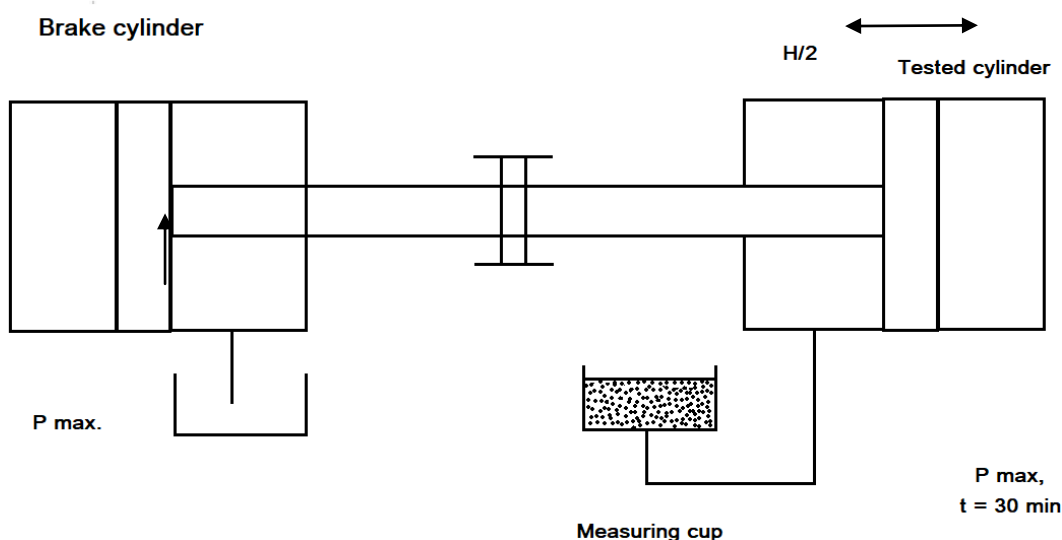


Figure 1 - Measurement of volumetric losses

3.3. Reliability testing

The normal procedure for testing cylinders for a century consists in operation of cylinders with normal (nominal) load.

The accelerated procedure for testing cylinders for life consists of operation of cylinders with 150% nominal load. Time of work can be defined as the distance traveled by the piston rod of the cylinders.

The following parameters are defined for these tests:

- Number of moves 1×10
- Piston stroke 75% of max. stroke
- Walking frequency $500 \div 1000$ walking/hour
- Pressure load $p = 0 \div p_{\max}$
- Frequency of testing 4 pieces/6 months
- Test sequence 90% stroke at 23 ± 3 °C
- 5% run at 40 ± 3 °C
- 5% stroke at 50 ± 3 °C

During the test and after the test, the cylinders must not show no functional and sealing defects. Loss of working fluid must not exceed 1% of the volume at a pressure of 100000 moves.

3.4. Other characteristics of cylinders

In addition to the mentioned tests, the following basic sizes are also measured:

- pressure (p_1) in the cylinder chamber on the side of the connecting rod during retraction,
- pressure (p_2) in the cylinder chamber on the side of the piston during extraction,
- temperature in the cylinder chamber on the side of the connecting rod (T_1),
- temperature in the cylinder chamber on the piston side (T_2),
- piston rod retraction time (t_1),
- piston rod extraction time (t_1),
- force on the piston rod of the cylinder during retraction (F_{k1}),
- force on the piston rod of the cylinder during extraction (F_{k2}).

The speed of retraction and retraction of the connecting rod is calculated according to the formula:

$$v = \frac{H}{t} \left[\frac{m}{s} \right] \quad (1)$$

Where: H- stroke connecting rod

t- time of insertion/extraction

The hydraulic-mechanical degree of utilization is calculated

as the ratio of the measured force on the connecting rod F_k and the theoretical force F_t .

$$\eta = \frac{F_k}{F_t} \quad (2)$$

$$F_t = p \cdot A \text{ [daN]} \quad (3)$$

where: p- pressure (bar)

A- projected area on which the force acts.

Lateral forces by their action on the guiding elements and sealing elements can significantly affect the results tests and prolonged action of these forces can cause permanent damage. Proper connection method ensures the accuracy of the examination, as well as the safety and protection of the examiner especially in the case when tests are performed with high pressures and maximum loads.

The cylinder test report should include the following data: test date, start of work, end of work, total working time per day, total working time so far, number of cylinders, numbers of cylinders that worked in conjunction and working time in coupling, working fluid, working fluid characteristics, temperature external environment. All visuals are also recorded in the report observations.

At the bottom of the report, a table is formed: by the serial number of measurements, pressure value at the pump, number of strokes per minute, cylinder stroke, oil temperatures, aggregates included, volumetric losses for cylinders 01 and 02, cylinders in coupling-pressure test and brake cylinder and note.

4. DIAGNOSTIC OF CYLINDER CONDITION

As part of the diagnostics of the hydraulic cylinder condition, the following parameters are assessed [1].

4.1. Assessment of the condition of the cylinder body

The cylinder body (tube) is first visually inspected, by placing it against a light source, where damage is determined (spots, corrosion, small or large cracks, lunkers, flakes, etc.)

Lighter damage such as stains, corrosion and minor scratches can be removed by polishing with fine sandpaper or polishing paste.

In case of major damage to the cylinder tube (larger scratches, dents, flakes), the repair procedure requires more complex activities (metallization).

The damaged cylinder tube is first immersed in a degreasing bath.

When the cylinder body is well degreased from the inside, the dechroming procedure follows, i.e. removing the applied chrome layer.

After that, the pipe is placed on the grinder for internal circular grinding and sanded to the depth of the largest damage on the pipe. The next activity is honing to a preparatory measure for chrome plating. Chromium plating is done by galvanic process with a maximum layer thickness of 0.05 mm.

At the end of the chroming activity, the opening of the cylinder tube is honed to the final size. The cylinder tube is thus ready for assembly.

If the inspection found that the cylinder tube has no major damage, it is possible to check the centricity and "inflatedness" using a comparator and a counter. Determined deviations from the permitted tolerances are eliminated by the processing procedure as in the case of major damages

4.2. Assessment of the condition of the cylinder piston

Diagnostics and repair of the piston is carried out by the following procedure [1]:

- possible damage to sliding surfaces is determined by visual inspection, tolerance deviations and shape deviations are determined by measuring with a micrometer,
- determined deviations are removed by machining the piston on a lathe, and then by the metallization process (hard metal casting)
- and with the final grinding, the kli is brought to the final measure,
- special attention should be paid to the correctness of the channel for the installation of sealing elements,
- possible defects are eliminated by processing procedures (scraping, metallization, grinding)
- the piston is also checked for porosity using defectoscopy methods
- (ultra sound, magnetic methods, penetrants, X-ray) since the piston is exposed to high pressures.

4.3. Assessment of the condition of the connecting rod

Diagnostics and repair of the connecting rod is performed as follows:

- visual inspection reveals minor damages (scratches of a depth of several hundredths of a millimeter, corrosion),
- by measuring, larger damages are determined (several millimeter-deep scratches),
- measurement determines the deviation of the connecting rod axis (warpness)
- minor damages can be repaired with a fine grinding stone or diamond emery paper,
- larger damages (several millimeter-deep scratches, large corrosion spots) are repaired by the machining process. First, the piston rod is machined on a lathe to the depth of the greatest damage, and then it is ground to the appropriate size on a circular external grinding grinder. Then, the metallization process is carried out with by first applying a layer of nickel as a base for chrome plating. The hard chrome plating process applies a layer of a maximum of 0.05 mm. The final processing of the connecting rod is performed on a grinder for round external grinding (fine grinding,
- polishing),

- after finishing the processing, a technical control is performed (measurement of tolerated measures, hardness of the surface layer, ovality, etc.), which
- the piston rod is ready for assembly after repair.

4.4. Assessment of the condition of other parts of the hydraulic cylinder

Diagnostics and repair of other elements is performed as follows:

- Defecting of the sealing material is done by visual inspection (with a magnifying glass) where the wear of the sealing edges is checked.
- In the case of major damage, the sealing material must be replaced. In practice, when renovating cylinders, the sealing material is usually replaced, given that the rubber is subject to natural aging and that the assembly of the cylinders is very complicated.
- Cylinder heads (front and rear) are checked by defectoscopy for porosity and cracks. The tolerances of geometric measures are also checked, especially the channels in which the sealing elements are placed,
- Renovation of adjacent surfaces and channels is carried out using processing procedures (scraping, sanding),
- Porosity and cracks are repaired by welding, and in the case of major damage, completely new cylinder heads must be made,
- Dampers (shock absorbers) are checked for functionality. In case of damage, new ones are made,
- The threaded connections are checked for damage, and the connection screws for stretching. In case of damage or stretching, it is mandatory to replace them with appropriate new threaded elements,
- Fuses, regardless of correctness, must be replaced with new ones.

5. CONCLUSION

The paper describes the method of testing the functionality of the hydraulic cylinder as a part of the hydraulic system, and describes the problem of assembly and disassembly as one of the reasons why special attention should be paid to proper and complete repair and maintenance of parts.

The aim of the work is to show and facilitate the understanding of both the way of functioning and the way of establishing the cause of failure and its elimination.

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