Layout Experimental Study of Dynamic Parameters of an Asymmetrical Self-Oscillating Hydraulic Drive

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Abstract. The article describes the developed asymmetric self-oscillating hydraulic drive and a stand for determining its dynamic characteristics. The design feature of the self-oscillating drive is that the switching of the working fluid in the cylinder cavity is made by two spools mounted inside the piston, while the working fluid is supplied to the spools by the hollow rod. The test stand is based on the principle of throttling the working fluid when it flows from one cavity of the loaded hydraulic cylinder to another. Stand tests of the developed drive have shown its reliability at different values of the piston stroke and at different operating pressures. The paper presents the characteristics of the drive when operating under load and at idle.

1. Introduction

Hydraulic drives, due to their features, are increasingly being implemented in modern technological systems. A special role among them is played by asymmetric hydraulic self-oscillating drives that work in confined conditions and during mining. They have significant forces on the main stroke and sufficient when idling, which increases the efficiency of the drive.

Development, production, testing, and regulation of self-oscillating hydraulic drives require mandatory testing of finished samples. At the same time, the specific application of these hydraulic drives makes it necessary to develop special stands for their experimental research and acceptance trials. Analysis of well-known stands for testing hydraulic drives shows that their implementation requires a large amount of equipment (measuring, shut-off, throttle, as well as special hydraulic lines) to ensure their operation. Creating an easy-to-use, simple and compact stand for measuring parameters and experimental research of parameters of an unbalanced self-oscillating hydraulic drive is an urgent task.

2. Statement of the problem

The development and creation of a drive presupposes a number of very difficult tasks for researchers. But one of the main tasks is to measure the dynamic parameters of the developed drive and their compliance with the goal. Hydraulic asymmetrical self-oscillating drive, due to its specificity, requires measurement of parameters, both on the stroke of the hydraulic cylinder rod extension and on the stroke of its retraction, which is the working stroke.

3. Theory

The main dynamic parameters to be studied are the speed of the hydraulic cylinder rod, and the value of the pushing and pulling nominal force of the hydraulic cylinder at the nominal pressure value during the movement of the hydraulic cylinder. According to GOST 18464-96 “Volume Hydraulic drives. Hydraulic cylinders. Acceptance rules and test methods”, it is allowed to measure the nominal force with a calibrated hydraulic cylinder, but the recommended stand described in the standard has a rather complex design, which includes a significant number of components [1]. To study the main dynamic parameters of an asymmetrical self-oscillating hydraulic drive, a stand is used to measure the operating parameters of an asymmetrical self-oscillating hydraulic drive [4], shown in figures 1 and 2. The stand includes a hydraulic tank 1, an adjustable hydraulic pump 2, connected by a liquid supply channel 3 to the body of the self-oscillating hydraulic drive 4 under study. The latter is attached to the body of the reference hydraulic cylinder 8 via the adapter coupling.
5, the bolted connection 6 and the connecting plates 7. The piston and rod cavities of the reference hydraulic cylinder are connected to each other by pipelines 9, which include pressure gauges 10 through throttles 11 with check valves. Rod 12, coaxially connected to the rod of the reference hydraulic cylinder 14 by coupling 13, is connected to the piston of the spool distributor 15 [3] and sealed with oil seals 16. To supply the working hydraulic fluid to the piston with a spool distributor 15, a central channel 17 is used, into which the working hydraulic fluid enters through a hollow rod 18. Control of the working fluid flow is carried out by spool 19 and 20. To determine the speed of movement of the rod 12 in the body of the self-oscillating hydraulic drive 4, a window 21 is made.

![Figure 1: Stand for measuring the operating parameters of an unbalanced self-oscillating hydraulic drive](image1)

**Figure 1.** Stand for measuring the operating parameters of an unbalanced self-oscillating hydraulic drive

The schematic diagram and an overview of the stand are shown in figure 3.

The stand for measuring the operating parameters of an unbalanced self-oscillating hydraulic drive works as follows. The working fluid under the pressure required for the movement of the piston with a spool distributor 15 is fed through the liquid supply channel 3. The rod 12 and the piston with the spool distributor 15 of the hydraulic cylinder 4 are in the extreme right position, and the spool with the stopper 20 and the spool without the stopper 19 are in the extreme left position. The left cavity of the

![Figure 2: Piston with spool distributors](image2)

**Figure 2.** Piston with spool distributors
hydraulic cylinder 4 is connected to the hydraulic tank 1 by channel 22 and is filled with working hydraulic fluid.

![Figure 3. Schematic diagram (a) and overview (b) of the stand for measuring the operating parameters of an asymmetrical self-oscillating hydraulic drive](image)

The working fluid is pumped into the channel 3 under pressure, which then flows through the hollow rod 18 to the piston with a spool distributor 15 into its Central channel 17, communicated with the spool cavity 19, (thereby filling the right cavity of the hydraulic cylinder 4.) As the right cavity of the
hydraulic cylinder 4 is filled with the working fluid, the piston with the spool mechanism 15, connected to the rod 12, moves to the left, carrying out its retraction – the working stroke. Upon reaching the piston with the spool dispenser 15 leftmost position, the spool 19 moves to the right, blocking the message from the Central channel 17 with the right cylinder chamber 4, while the spool 20 also moves to the right, telling the cavity of the right hydraulic cylinder 4 with its left cavity and the hydraulic tank 1 via the channel 22. There is a drop in pressure in the right cavity of the hydraulic cylinder 4, due to excessive pressure in the liquid supply channel 3, the piston with the spool distributor 15 moves to the right, extending the rod 12, after which the cycle repeats.

To measure the forces generated on the rod of an asymmetrical self-oscillating hydraulic cylinder, a hydraulic circuit has been developed consisting of connecting pipelines 9 and two adjustable chokes 11 with check valves that allow changing the pressure in the cavities of the reference hydraulic cylinder that pass the working fluid in only one direction. Pressure measurement in the cavities of the reference hydraulic cylinder is carried out with pressure gauges 10. The pressure in the cavity of the reference hydraulic cylinder is recalculated to the force generated by the rod 12, depending on the area of the piston of the reference hydraulic cylinder 8.

After starting the adjustable hydraulic pump 2, the throttles 11 are fully open, and the hydraulic fluid flows freely between the cavities of the reference hydraulic cylinder. After that, the operator gradually reduces the throughput of the chokes 11 until the clutch 13 (rod 12) stops, while the readings of the pressure gauges 10 are taken to determine the counteraction force equal to the force created on the rod 12 of the self-oscillating hydraulic drive.

4. Experiment
The study of the developed self-oscillating drive was carried out on different piston strokes; the working stroke was changed by adding/removing spacers between the lip seal of the tested hydraulic cylinder and the piston with a spool distributor. To evenly distribute the loads that occur during the operation of the self-oscillating hydraulic drive, spacers were placed on both sides of the piston.

To study the power parameters of the drive, the piston stroke was set to 250, 400, 500 and 1000 mm. The main parameters of the self-oscillating hydraulic drive were measured in the steady-state mode of operation: the pressure at the inlet of the tested hydraulic cylinder at the inlet stroke/output - time of extension and retraction of the rod, pressure indicators on the load cylinder pressure gauges at the time of complete stop of the rod on the input and output cycles.

The results of the experiment and the dependences of the main characteristics of the self-oscillating hydraulic drive, determined using the developed stand, are shown below.

5. Results and discussion
The data indicate that the developed asymmetrical self-oscillating hydraulic drive is capable of considerable effort on the rod, as can be shown by indicators pressure gauges measuring stand, while the estimated power parameters of the hydraulic drive as a whole do not exceed the parameter values obtained experimentally. The difference was not more than 8 % due to leakages the test cylinder.

6. Conclusion
In conclusion, the design of an asymmetrical self-oscillating hydraulic drive has been developed, which has a wide range of applications, especially in mining-related fields. Besides, to measure on-load parameters of an asymmetrical self-oscillating hydraulic drive, which has a wide range of applications in cramped conditions and especially in the field of mining, a special stand having easy-to-manufacture and easy-to-use design has been developed and is now applied. The conducted experiment proves the efficiency and accuracy of determining the dynamic parameters of the hydraulic drive when testing it on the developed stand. At the same time, the implementation of the load circuit of the test stand is possible in a number of variations. To obtain more accurate results, it is advisable to conduct tests when forming a mechanical load on the rod of the hydraulic drive.
Figure 4. Graphs of the rod velocity (a), the force on the retraction stroke (b) and the force on the extension stroke (c) from the pressure.

7. References
[1] Russian Federation State Standard (GOST) 1996 18464-96 *Volumetric hydraulic drives. Hydrocylinders. Acceptance rules and test methods: approved and put into effect* Interstate Council for standardization, Metrology and certification Protocol No. 10 of October 3, 1996.

[2] Varsonofiev V D and Kuznetsov O V 1979 *Hydraulic vibrators* (Leningrad, Mechanical engineering Leningrad Division-II).

[3] Kilunin I Yu, A Buryan Yu, Sorokin V N et al. 2018 Russian Federation Patent No. 186582, 13.08.2018, *Device for hydro-impulse impact on the bottom-hole zone of the formation* Bul No 3.

[4] Kilunin I Yu, Sergeev S S, Sorokin V N et al. 2019 Russian Federation Patent No. 197722, 31.12.2019 *Stand for measuring the operating parameters of an unbalanced self-oscillating hydraulic drive*, Bul No 9.