

Designs of self-acting valves of reciprocating compressors

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The conducted review analysis of the existing designs of self-acting valves showed a variety of design designs. However, all the presented designs contain all the main parts – this is a locking body, a seat, a spring and a lift limiter. At the same time, different valve designs are adapted to different operating conditions.

Keywords: reciprocating compressor, self-acting valve, resource, workflow.

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I. Introduction

The valves of the volumetric principle of operation machines are divided by purpose into valves that serve to communicate a low-pressure cavity with a working chamber, that is, to let the working medium into the compression chamber – called suction valves; the second type of valves serves to communicate the working chamber with a high-pressure chamber, that is, to release the working fluid from the compression chamber - The discharge valves are called. The operation of self-acting valves is based on overcoming the elastic forces closing the valve due to the pressure difference on one side and on the other side of the valve. Figure 1 shows a schematic diagram of a self-acting valve [1-3].

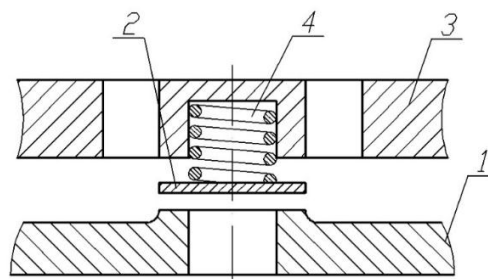


Figure 1 – The basic device of a self-acting valve:
1 – seat; 2 – locking body; 3 – lifting limiter; 4 – spring

The valve works as follows: in the closed state, the shut-off valve 2 is located on the seat 1 pressed by a spring 4, when a pressure difference occurs before and after the valve sufficient to overcome the stiffness of the spring 4, the shut-off body begins to move towards the lift limiter 3 (the valve begins to open) with the valve fully open, the shut-off body is pressed against the lift limiter 3; as only the pressure drop on the valve decreases to such a value that the force of the spring 4 exceeds the resulting gas forces, the spring 4 closes the valve – moving the shut-off valve 2 to the seat 1.

Thus, the valve seat serves to accommodate the shut-off body at times when the valve is closed, that is, the shut-off body is pressed against the seat; the shut-off body serves to overlap the valve section and isolate the working chamber from the suction or discharge cavity; the spring ensures that the shut-off body is pressed against the seat and returns the shut-off body to its original state when closed; lifting limiter it serves to ensure the necessary stroke of the locking body.

This is how almost any self-acting valve works with four components. Consider the designs of modern valves.

The main part

Currently, there are a huge variety of different designs of self-acting valves. For example, for medium and high-pressure reciprocating compressors, self-acting annular valves are used [4-7].



Figure 2 – Hoerbiger ring valve

This company (Hoerbiger) manufactures and supplies disc and ring self-acting valves with shut-off rings made of titanium material, which have a working capacity of 10,000 hours [8].

Lobe valves are recommended for high-speed reciprocating compressors (N more than 1500 rpm) [9].



Figure 3 – T-shaped lobe valve

In high-pressure and low-capacity reciprocating compressors, flat or spherical disc valves are used [10].



Figure 4 – Disc valve

The structural elements in the above valves are made of metal material. But in modern design solutions for the implementation of gas distribution organs, elements made of non-metallic materials (elastomers) began to be used, namely for the coupling of the seat and the locking body, and the lifting limiter - the locking body.

Valves developed by the Swiss company Burckhardt Compression are known to reduce noise and vibration levels due to non-metallic plates [11]. It is suitable for use in difficult application conditions with gases containing oils and solids, as well as with pure gases such as oxygen. The optimized flow area reduces pressure drop and increases efficiency. According to technical data, these valves are used in compressors with a rotation speed of no more than 1000 rpm, a pressure drop of up to 170 bar, a temperature range from -200 to $+220$ °C, with valve diameters from 40 to 383 mm. The advantage of these valves:

- Outstanding performance when operating with contaminated gases, reduced oil adhesion;
- reduced sensitivity to various kinds of thermal expansion and moisture contained in the gas;
- less clogging than in disc valves when using polluted and humid gases;
- Improved flow path aerodynamics, reducing pressure drop and increasing efficiency;
- Noise and vibration reduction;
- reduced sensitivity to changing operating conditions;
- minimal risk of secondary damage to compressor parts in case of breakdown;
- Metal springs are protected from gas flow by a non-metallic plate body.

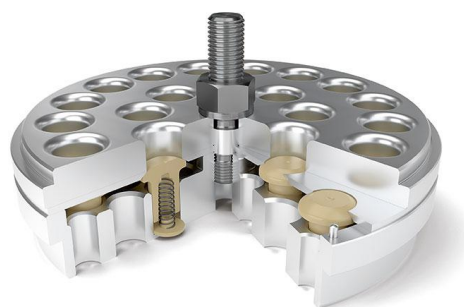


Figure 5 – Disc valve Burckhardt Poppet Valve

When operating a self-acting valve (suction or discharge), the shut-off element of the valve, when fully opened, hits the limiter, which leads to shock loads that can lead to increased wear of the mating elements. To solve this problem, an elastic element is installed on the limiter to reduce shock loads.

For example, there is a patent for a utility model "Self-acting spherical poppet valve" by the author B.I. Ingnatov (Republic of Belarus).

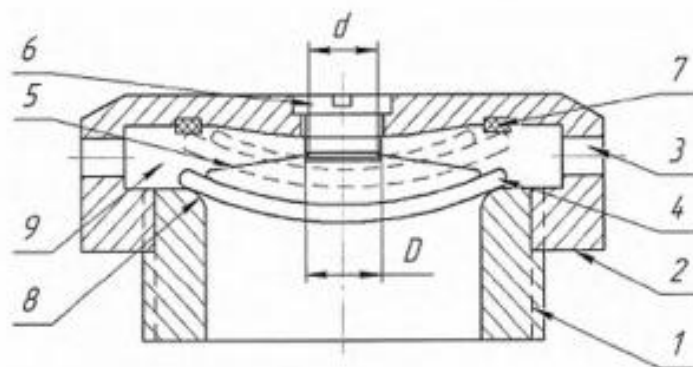


Figure 6 – Self-acting spherical poppet valve: 1– seat; 2 – lifting limiter; 3 - channels for gas passage; 4 – spherical plate; 5 – flat spring; 6 – adjusting screw; 7 – an insert made of elastic material; 8 – the area where the plate fits on the saddle; 9 – valve body

The self-acting spherical poppet valve contains a seat 1, a lift limiter 2 with channels for gas passage 3, a closing part in the form of a spherical plate 4, a flat spring 5 with a nonlinear elasticity characteristic, a control screw 6, an insert 7 made of elastic material.

The opening of this valve begins at the moment when the piston speed is close to maximum. Therefore, when the valve is opened quickly, strong impacts of the plate on the lift limiter are possible. To reduce the impact forces at the time of landing the plate on the lift limiter, it has an insert 7 made of elastic material. Also, to reduce shock loads, the shut-off element of the valve can be made of elastomeric material.

The patent of an annular self-acting valve by the author O.K. Shkodzinsky is known.

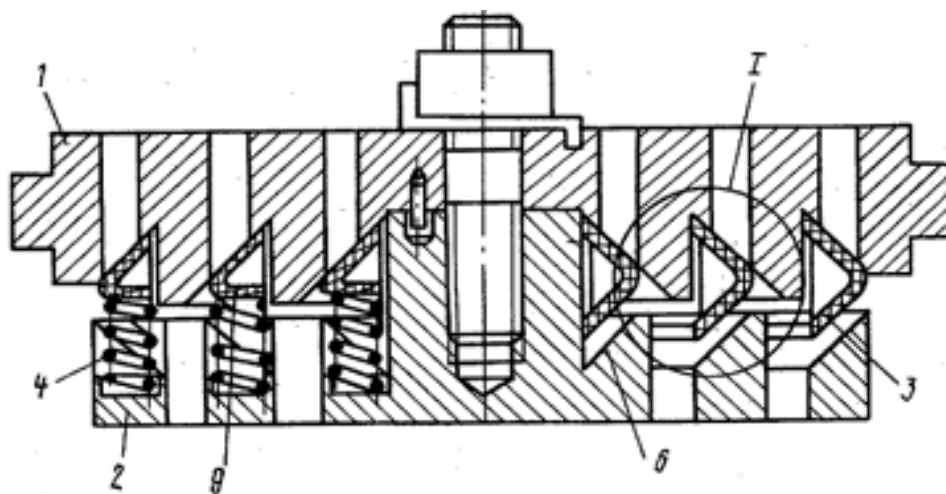


Figure 7 – Self-acting spherical poppet valve

The valve contains a seat 1, a lifting limiter 2 and an annular shut-off body located between them 3, spring-loaded to the seat 1 by local springs 4 and alternately in contact with the seating surfaces 5 and 6 of the seat 1 and the limiter 2. The shut-off body has a V-shaped cross section with a vertex 7 facing away from the valve, and it is equipped with stiffening ribs 8 and sockets 9 for springs, located on the side of the lift limiter 2. The landing surfaces 5 and 6 are made conical, according to the profile of the charging body 3, the locking body itself is made of non-metallic. The purpose of the invention is to increase the efficiency and durability of the valve. The locking body, hitting alternately the seat and the limiter, perceives shock loads, which partially turn into a compression stress of the ring around the perimeter, which is less dangerous for the locking body.

There are valves in which the pre-compression of the locking element is carried out not by a spring, but by a pair of magnets. KSK-Service LLC manufactures and sells disc, ring and disc self-acting valves with an operating temperature of up to 200 ° C and a discharge pressure of up to 40 MPa. The service life of these valves

is up to 25,000 hours. The valves differ in that a pair of magnets are used instead of a spring, the author of the invention Dudarenko A.P.



Figure 8 – Ring valve

The new line of valves for drilling pumps of OZNA-Oktyabrsky Mechanical Plant LLC allows you to work without knocking and increase the average time to failure by 10-15%, by eliminating the impact of the plate on the saddle crosspiece. The service life of such valves is more than 5,000 hours [12,13].

Dresser-Rand develops and manufactures valves that set a new level of requirements for reliability, service life, efficiency, cost and production time – the Magnum valve, which is installed in lubricated and dry compressors pumping gases from almost pure hydrogen to methane and dirty carbon dioxide at rotational speeds from 327 to 1000 rpm and discharge pressures from 2.5 to 280 bar. the service life of the valve is 25,000 hours [13].

II. Conclusion

The considered designs of self-acting valves have found wide application in various types of compressors. Depending on the design, certain schemes are used for low-pressure and high-pressure stages, so direct-flow valves with lower hydraulic losses have found application in low-pressure stages. Ring and disc valves are used in high-pressure stages.

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