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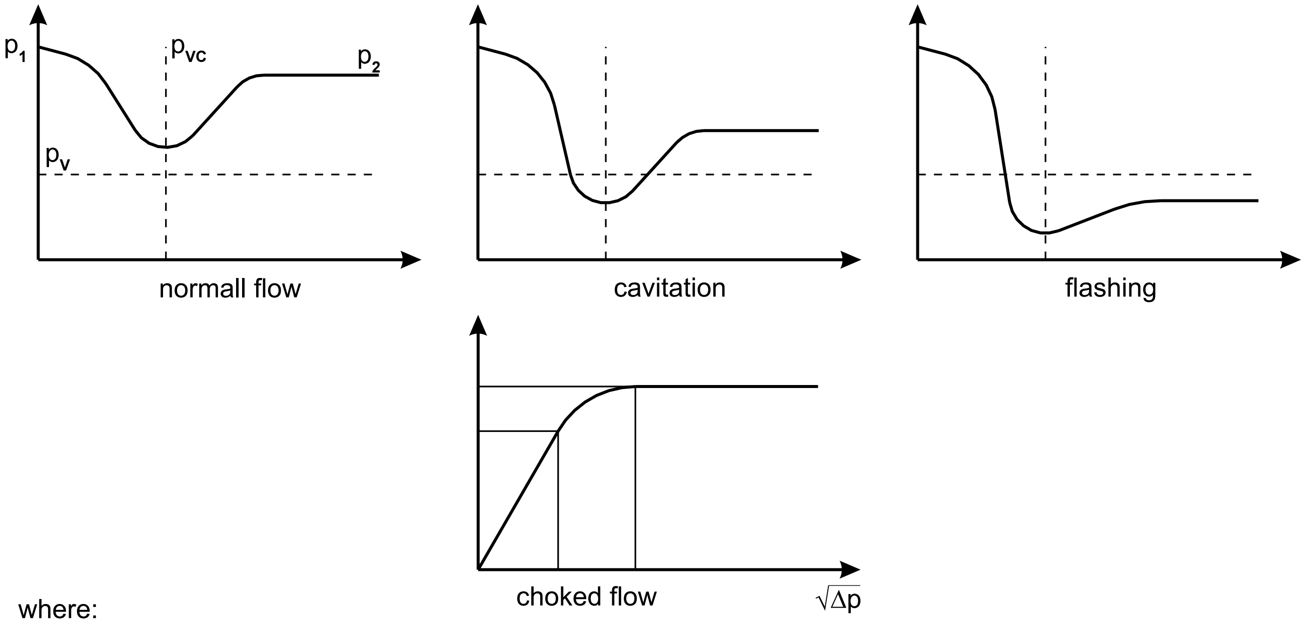
HARMFUL PHENOMENA IN THE WORK OF VALVES. - **TECHNICAL INFORMATION**

The flow of medium through the valve (depending on the kind and parameters of the medium) may cause phenomena having a negative impact on the environment and be destructive to the product’s durability.
Risk factors should be diagnosed in detail in order to be used for actions aimed at limiting or eliminating their negative influence.
Harmful phenomena connected with the flow include the following factors:

- Noise
- Cavitation
- Evaporating (flashing)
- Choked flow

The conditions in which the above-mentioned phenomena occur are explained by the following graphs:



where:
p_1 - pressure before the valve,
p_2 - pressure after the valve,
p_{vc} - pressure in the “vena contracta” zone,
p_v - pressure of evaporating.

Medium flowing through valve shall invariably cause noise.
Adverse effect of noise is due to its harmful effect to health and working environment. Noise is also the symptom of processes inside the valve, generally reducing durability of appliance, including damage.
Noise level is measured in [dBA] units, 1 m from the pipeline surface and valve axis, in the direction to medium outlet.
Human ear is most sensitive to frequencies 3000 to 4000 Hz. Allowable workplace noise level depends on duration of exposure. For continuous work it is 85 dB(A), for short exposures, say 15 minutes a day, it is up to 115 dB(A). 3 dB(A) difference means double increase in noise level; hence two appliances generating 82 dB(A) are equivalent to one appliance generating 85 dB(A). Noise level drops by 3 dB(A) with each doubling of distance from pipeline.

Sources of valve noise emissions may be as follows:
- mechanic noise,
- aerodynamic noise,
- hydrodynamic noise.

Mechanic noise may be caused by vibrations of valve internal parts, resonance, misguiding of moving parts, excessive clearance. One of the methods to eliminate such noise is application of cage construction and selection of proper clearances to valve working conditions.

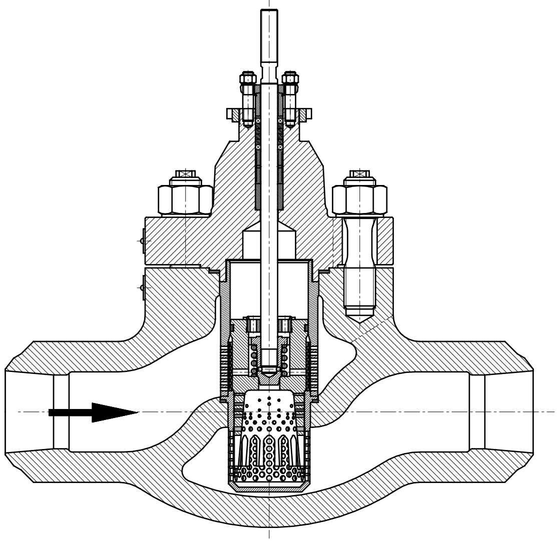


Fig. 1. Valve for high pressure and high temperature operation

In Fig. 1 a valve is shown designated for operation at temperatures up to 500°C, with possibility of thermal shocks. Valve plug is guided in valve seat and in cage. Application of steel spring ring allows increase of clearance between valve plug and cage without causing vibrations and loss of tightness. Mechanic vibrations can also be reduced through change in valve plug weight and direction of medium flow.

Aerodynamic noise is generated when mechanic energy of compressible medium flow is transformed to acoustic energy. Source of noise is increase in flow speed due to medium decompression, often exceeding speed of sound.

Noise reduction can be achieved by means of using proper installation (insulation on outlet pipeline, increased thickness of pipeline walls), or by means of selecting proper valve construction. The most important and most efficient way is to apply in valve perforated control structures in the form of perforated valve plugs (Fig. 2) or cages (Fig. 3).

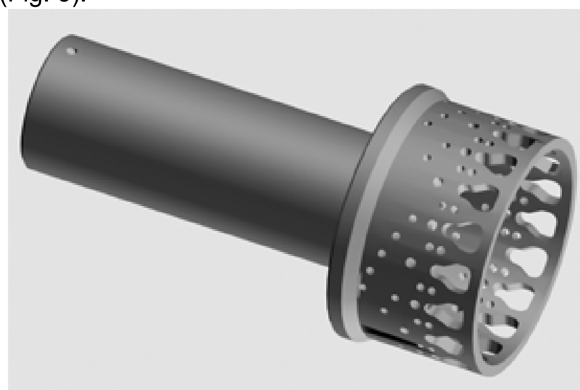


Fig. 2. Perforated valve plug

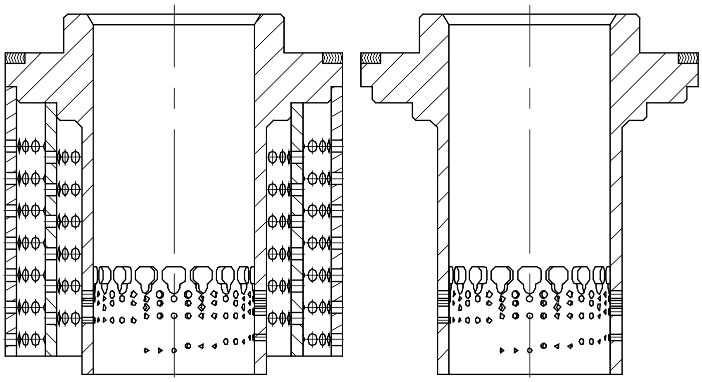


Fig. 3. Perforated control cages

Splitting of a single stream to multitude of smaller, well adjusted streams, causes reduction in noise emission as high as by 10 dB(A), due to following:
- reduction in efficiency of mechanic to acoustic energy transformation,
- smaller spin causes generation of higher frequency energy, which is easier to damp by walls and insulation,
- high frequency sound (> 10 000 Hz) is less harmful to human ears.

Another way of reducing aerodynamic noise (by ca. 5 dBA) is reduction in medium outflow speed at outlet. The most common method of doing so is increasing the outlet pressure by application of choking structures in the form of perforated cages and plates, and application of diffusers. In cases of high noise level it is often necessary to apply all those solutions at the same time (Fig. 4).

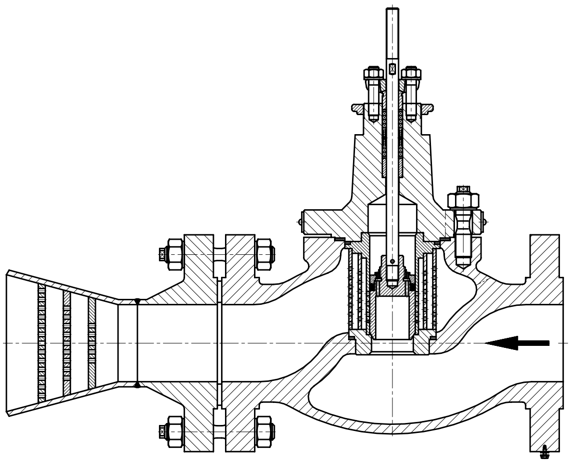


Fig. 4. Valve for compressible media to operate in noise and choked flow

Fig. 5. Damage of valve due to cavitation

Fig. 6. Damage of valve due to flashing

Hydrodynamic noise is generated by flow of fluids, and its sources can be as follows:

- turbulent flow interacting with valve and pipeline walls,
- cavitation,
- evaporation (flashing).

Cavitation consists in local, usually in vena contracta area, evaporation of fluid due to pressure drop below evaporation pressure p_v. Then, due to valve outlet pressure increase to value $p_2 > p_v$, implosion of generated steam bubbles occurs. In addition to noise, such a phenomenon features sudden accelerations and blows of two-phase mixture (fluid-steam), and resulting damages (Fig. 5) to valve or pipeline surfaces.

Should outlet pressure stay lower than evaporation pressure ($p_2 < p_v$) fluid is permanently turned to mixture of fluid and steam, with steam share depending on pressure and temperature.

This phenomenon is called evaporation (flashing).

Then sudden increase in flow volume and speed occurs. Mixture stream erodes internal valve surfaces (Fig. 6) and pipeline, and is the source of noise as well. The most harmful phenomenon is however cavitation. Its effect can be reduced by means of application of proper materials and surface hardening technologies on one hand, and application of design methods for elimination or controlling of cavitation on the other hand.

Another proven methods are: improving valve plug and valve seat durability by stelliting their phases or whole trims, diffusion or plasma nitriding, allowing achievement of surface hardness 950 HV to the depth of ca.0.1 mm, or through hot-setting to hardness 55 HRC. The basic design solution of anti-cavitation valves is execution with multi-stage valve plug (Fig. 7). The concept behind that solution is possibility of achieving pressure drops on each stage below critical value. It is however difficult to achieve effective choking on individual stages at the beginning of valve opening. In such cases we use contoured and perforated multi-stage valve plugs, with active structures which resistance depends on valve opening, and passive structures, in the form of cages and perforated plates (Fig. 8).

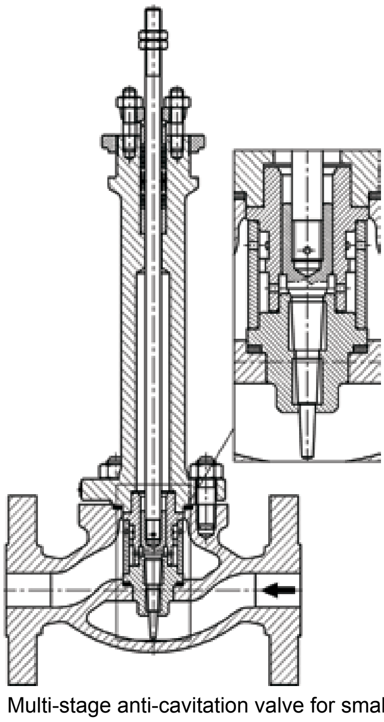


Fig. 7. Multi-stage anti-cavitation valve for small flows

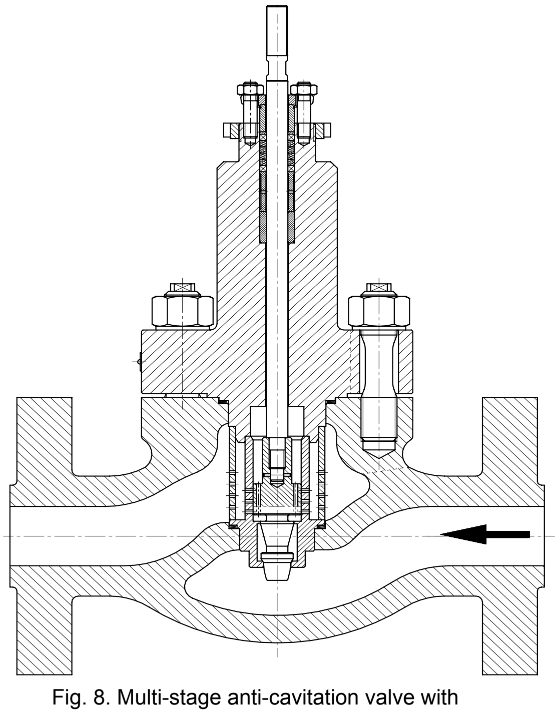


Fig. 8. Multi-stage anti-cavitation valve with various choking structures

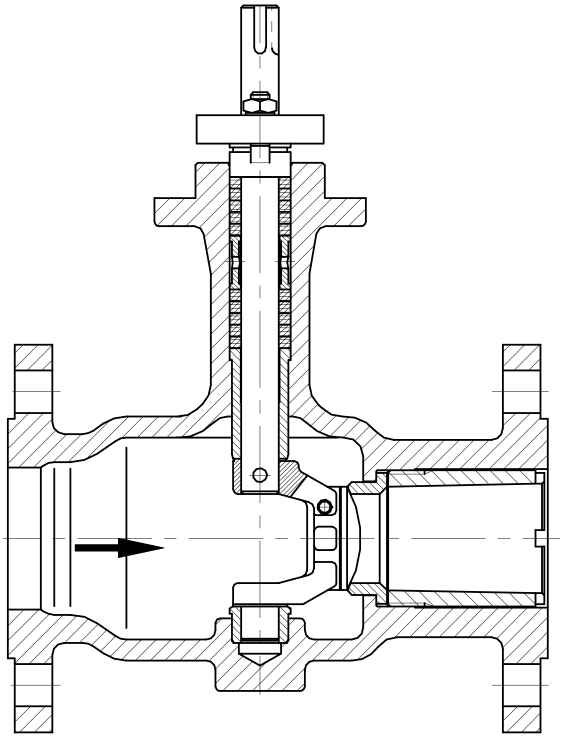


Fig. 9. Rotary valve for operation In flashing conditions

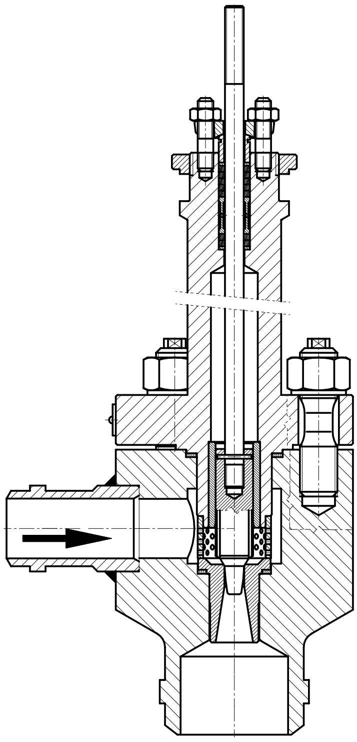


Fig. 10. Angle valve with anti-erosion seating

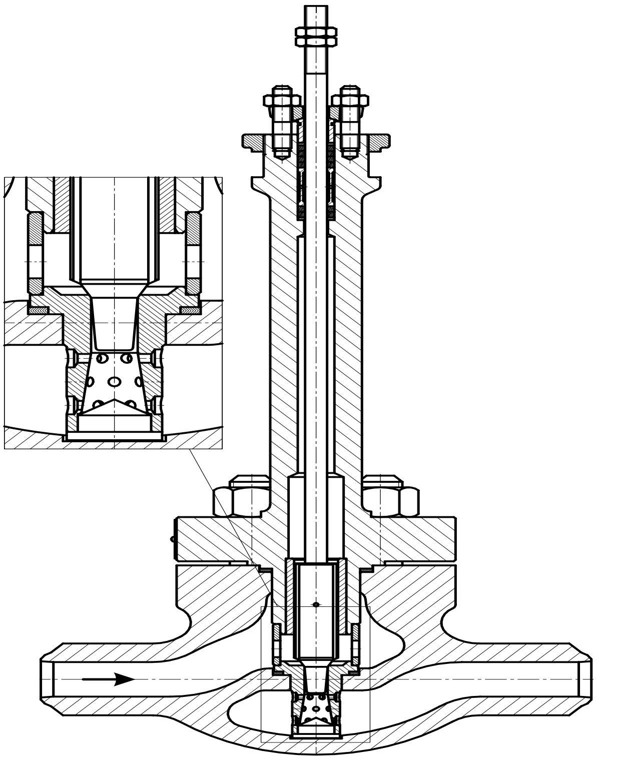


Fig. 11. Valve fitted with protective cage

Although occurrence of flashing depends only on flow parameters, and cannot be eliminated through design changes, its damaging effects can - and have to – be eliminated.

In addition to above discussed methods of improving durability of valve components, POLNA offers also application of hardening coatings on internal valve body surfaces, and application of valves fitted with anti-corrosion bushing (Fig. 9); angle valves (Fig. 10); and valves with protective cage (Fig. 11).

All above noise reduction methods applied in control valves by Zakłady Automatyki POLNA SA in Przemysl, are tailored to Customers' needs.

We design our valves after thorough analysis of phenomena occurring in flow process, based on detailed data and using specialized computer software DiVent and CONVAL®. Not only do our designs meet all standards, but also they solve problems the Customer's are unaware of.

CONVAL® software has a Polish version, made by our own company, and contains data about the POLNA product offer.