

Numerical analysis of flow and cavitation characteristics in a pilot-control globe valve with different valve core displacements

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Pilot-Control Globe Valve

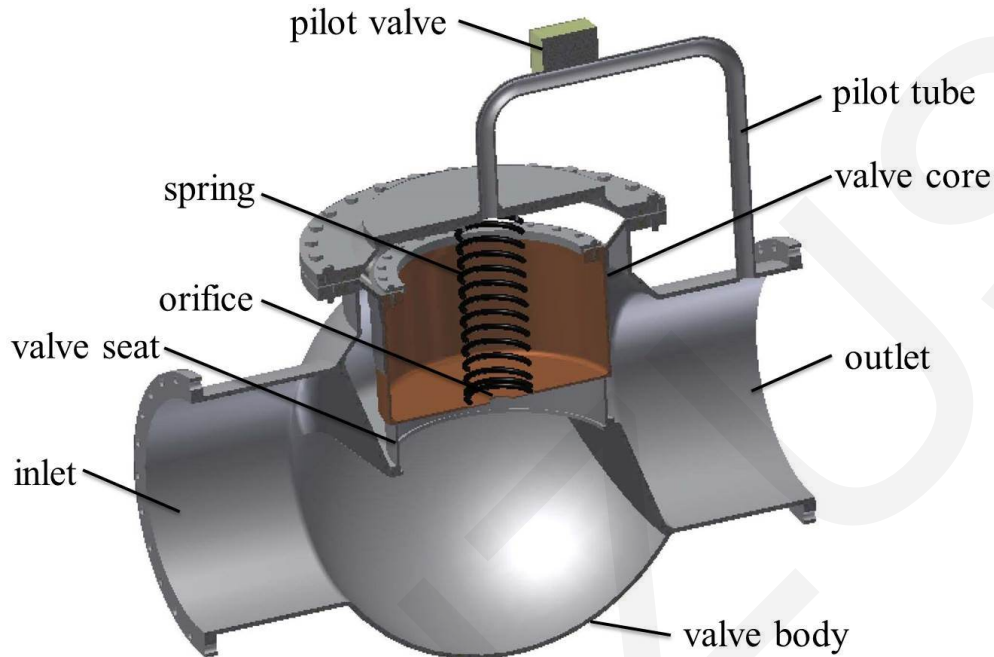


Fig. 1. Pilot-control globe valve and its key parts.

The pilot-control globe valve (PCGV) is a novel globe valve with a piston-type valve core and a small pilot valve. It can utilize a pressure difference to control the state of the main valve by the pilot valve. Instead of driving the main valve directly, PCGV uses the pilot valve and it has a low driving energy consumption.

Numerical Model

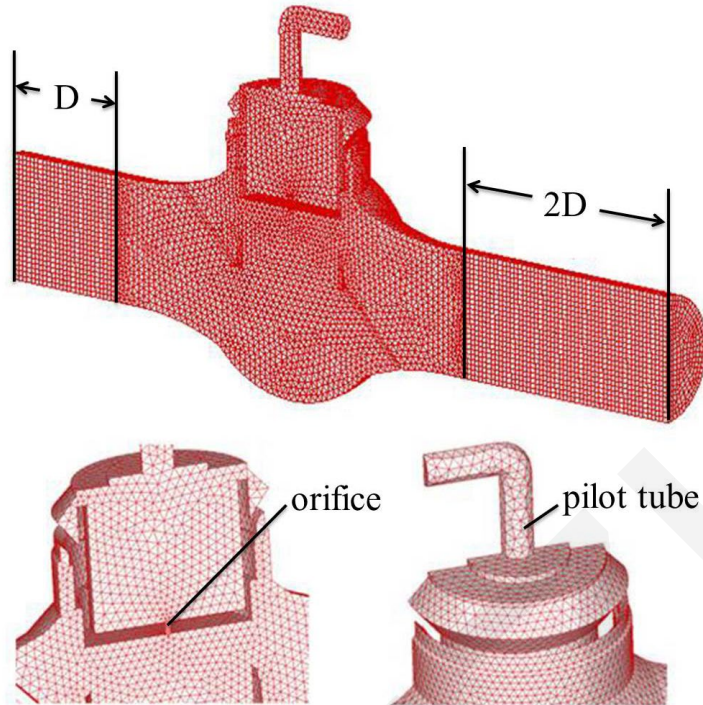


Fig. 2. Mesh of PCGV with valve core displacement 25 mm.

The cavitation model we used is based on the Rayleigh-Plesset equation.

$$\frac{\partial}{\partial t}(\alpha\rho_v) + \nabla(\alpha\rho_v v) = R_e - R_c,$$

$$R_e = \frac{3\alpha\rho_v(1-\alpha)\rho_l}{\rho R_b} \sqrt{\frac{2(p_v - p)}{3\rho_l}}, \text{ when } p_v \geq p,$$

$$R_c = \frac{3\alpha\rho_v(1-\alpha)\rho_l}{\rho R_b} \sqrt{\frac{2(p - p_v)}{3\rho_l}}, \text{ when } p_v \leq p,$$

Grid independence check is carried out under open condition by taking the pressure difference as the judgment parameter.

Opened and Closed States

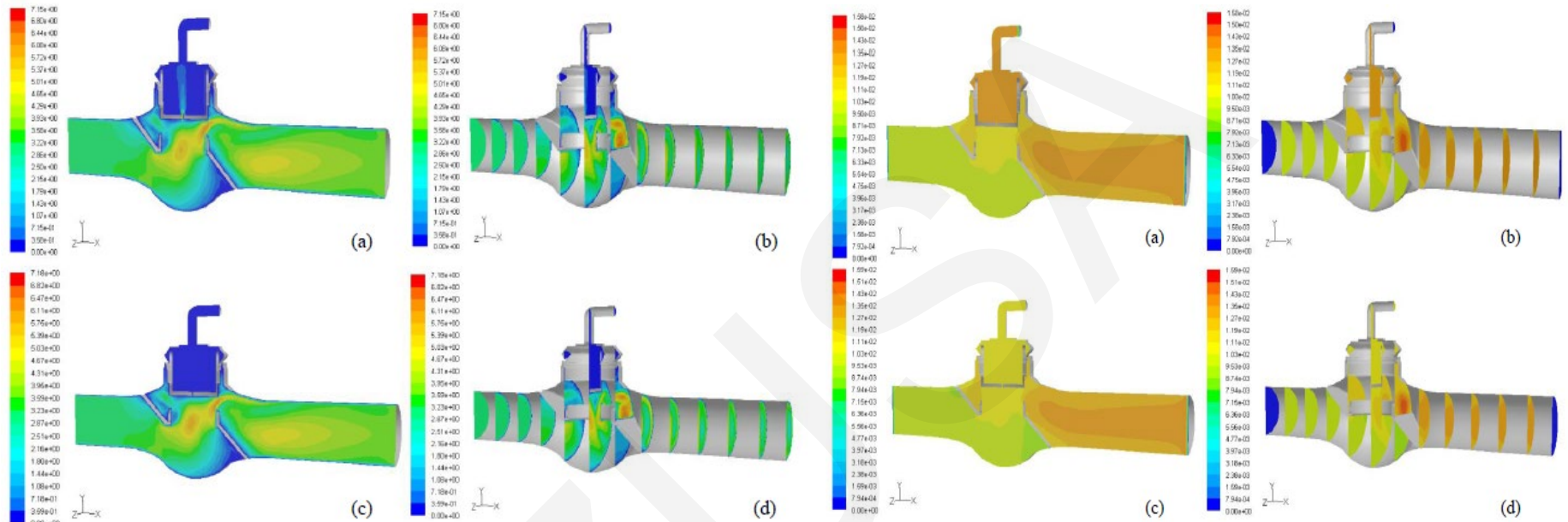
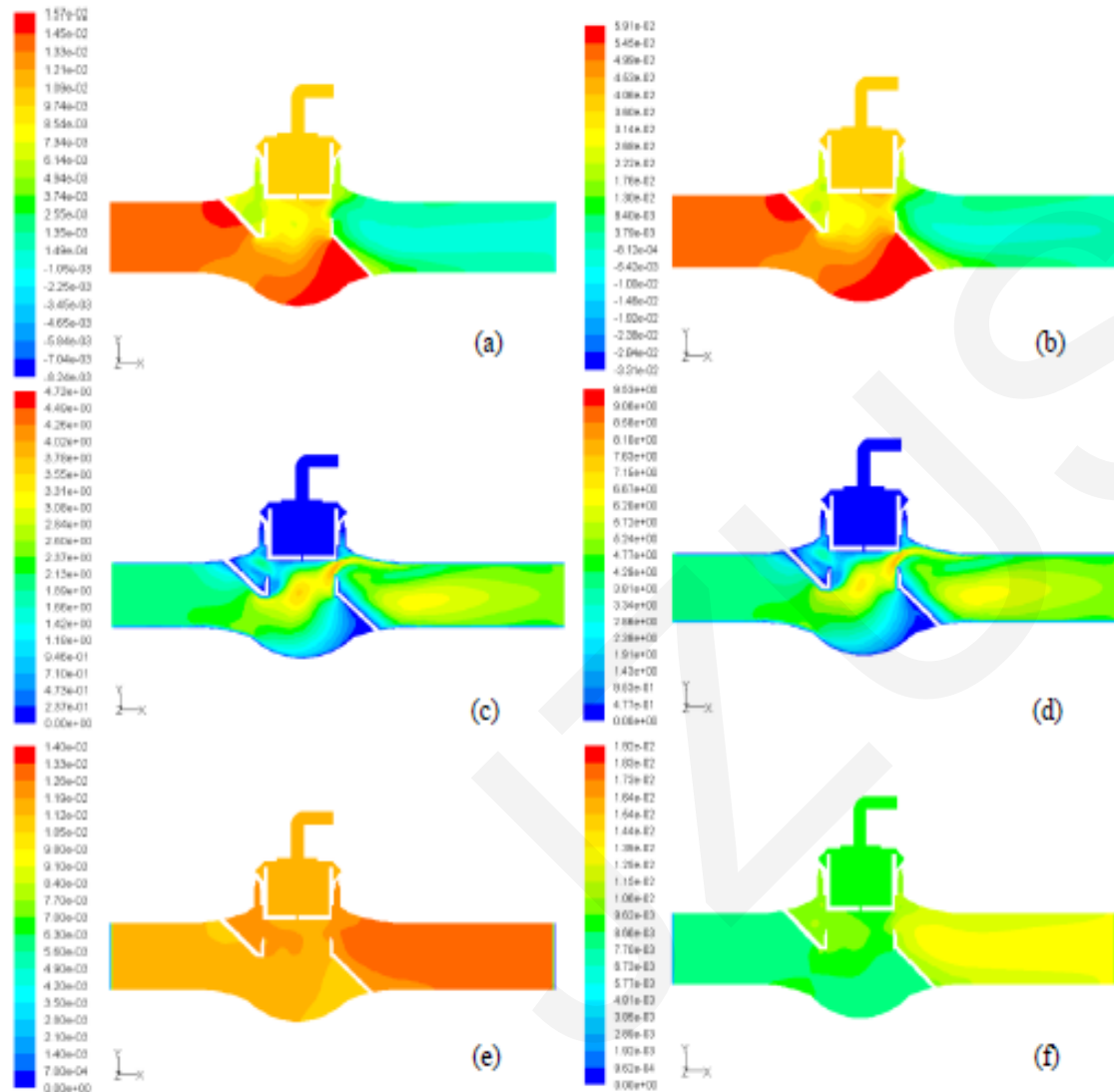


Fig. 4. Velocity contours under opened and closed states with valve core displacement at 25mm, inlet velocity 3m/s

Fig. 5. Vapor volume fraction contour under opened/closed states with displacement at 25mm, inlet velocity 3m/s

In both opened and closed states, at the point of the valve seat before the outlet tube, the velocity and the vapor volume fraction reach a peak.

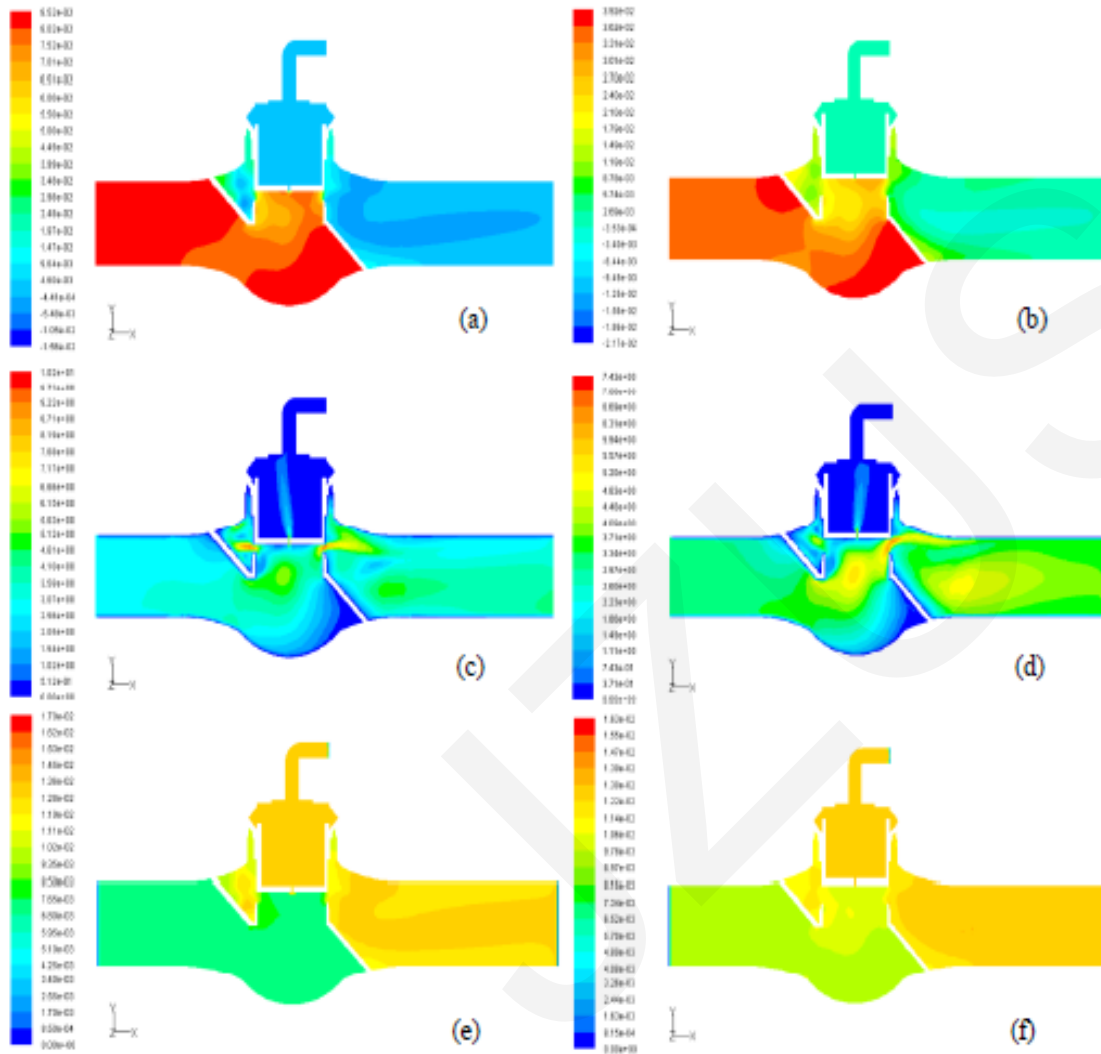
Different Inlet Velocities



Comparing pressure contours and velocity contours, they have similar contours but with different magnitudes. with the higher inlet velocity, PCGV opens more quickly since the pressure difference is much higher.

Fig. 6. Pressure, velocity and vapor volume fraction contours under closed, inlet velocities 2 or 4 m/s

Different Valve Core Displacements



At both 10 mm and 20 mm of valve core displacement, there is always a part with no velocity. It is located at the bottom of the main valve in the outlet direction.

Fig. 7. Pressure, velocity and vapor volume fraction contour under opened states under valve core displacement at 10mm and 20mm

Conclusions

- At both open and closed states, at the point of the valve seat before the outlet tube, the velocity and the vapor volume fraction reach their peak. Material at this part shall be strengthened by hardening.
- With a higher inlet velocity, PCGV can open more quickly, and the range of distribution of vapor volume fractions increases, but a greater cavitation does not follow because the pressure in the inlet part is also higher, which can inhibit the generation of cavitation.
- During the design work of limited structure, choose a suitable spring to make the operating position as high as possible. And the bottom of the main valve in the outlet direction should further optimization.