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Effect of valve core shapes on cavitation flow through a sleeve regulating valve

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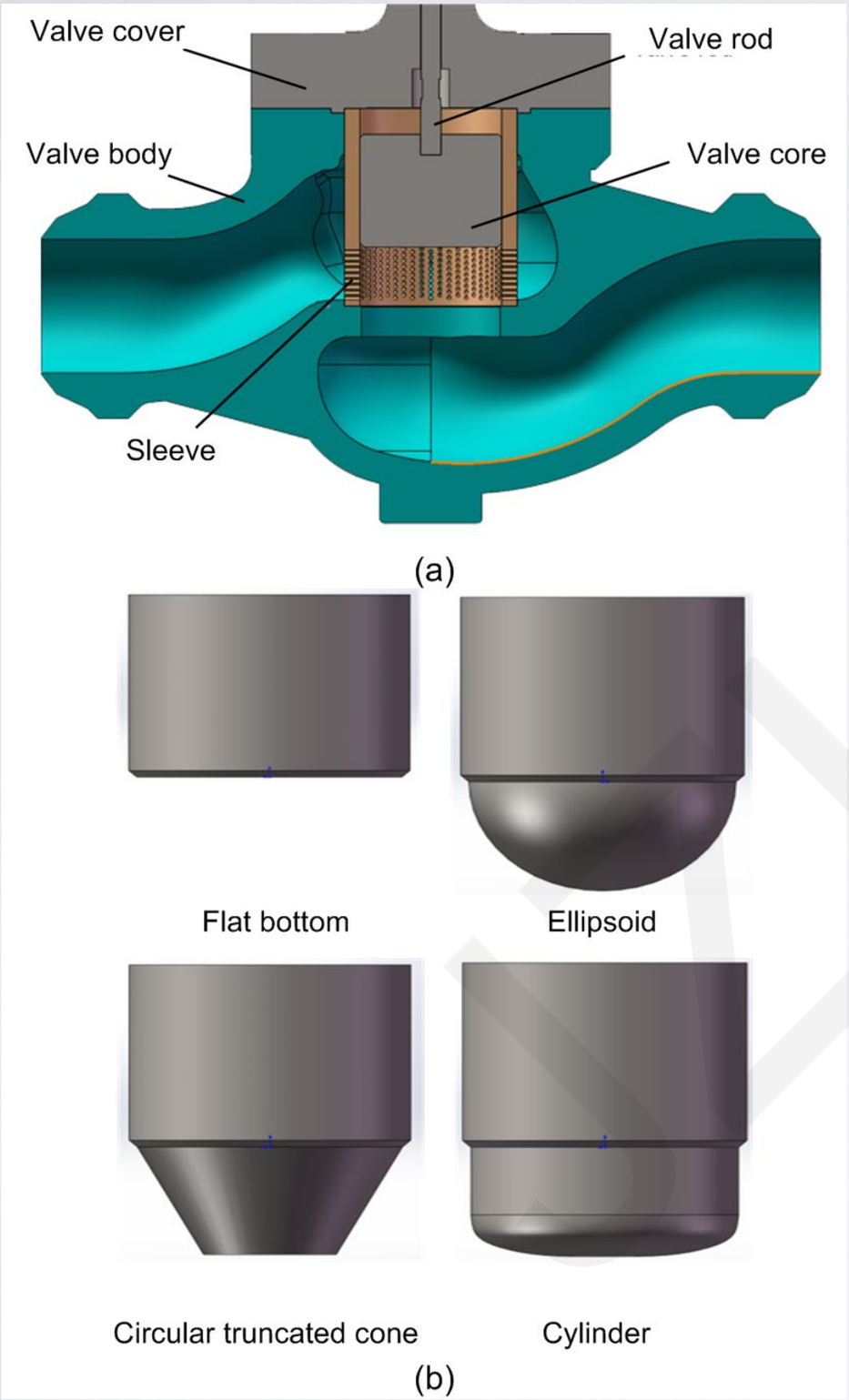
Key words:

Sleeve regulating valve, cavitation intensity, valve core shape, total vapor volume

Research summary



This study aimed to analyze the effect of the valve core shapes on the flow and cavitation characteristics of the sleeve regulating valve for different valve core displacements

- A multiphase cavitation flow model was established to simulate the cavitation inside a sleeve regulating valve
- Four valve core shapes including flat bottom, ellipsoid, circular truncated cone and cylinder were proposed and explored
- The velocity, pressure and cavitation distributions inside the sleeve regulating valve for four different valve cores were analyzed and compared
- The flat bottom and circular truncated cone valve cores are recommended for their better performance in reducing cavitation.

Analysis methods

Mathematical model

- Standard k-ε turbulence model
- Mixture multiphase flow model
- Schnerr-Sauer cavitation model

Vapor transfer

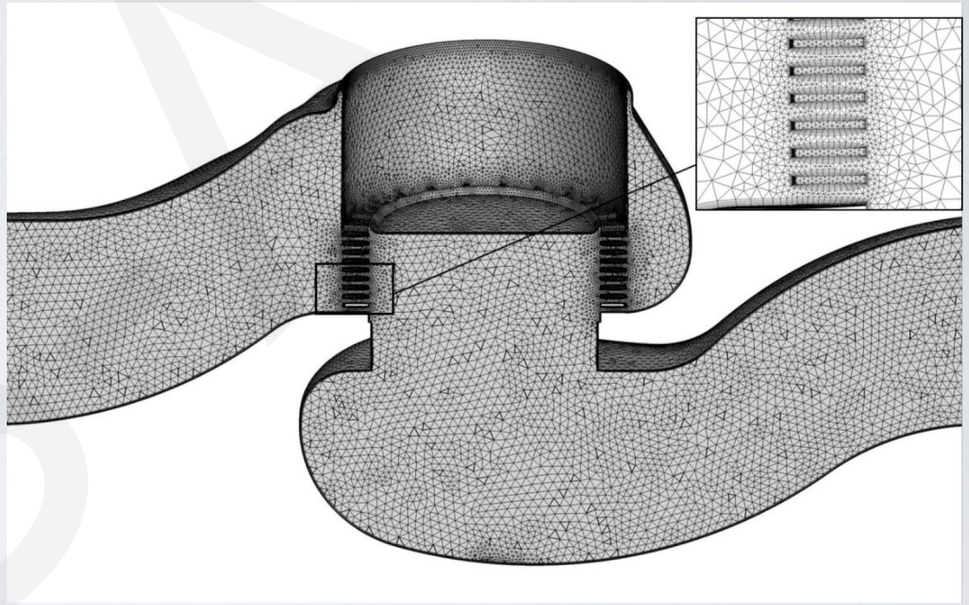
$$\frac{\partial}{\partial t}(\alpha\rho_v) + \nabla\cdot(\alpha\rho_v \boldsymbol{v}_v) = R_e - R_c,$$

Bubble growth

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

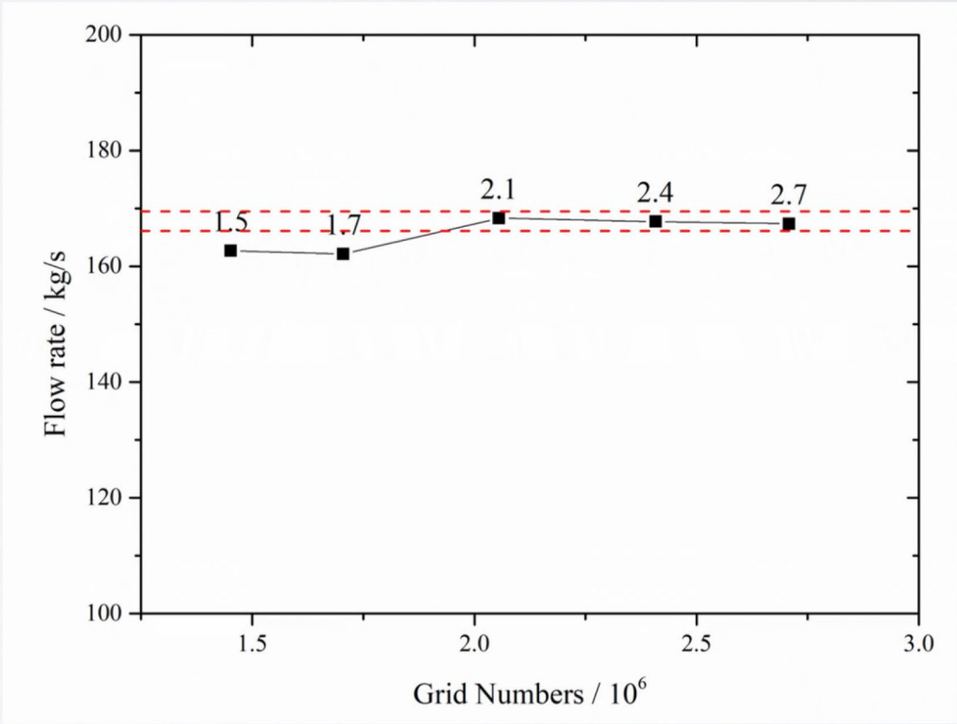
Bubble collapse

$$R_e = \frac{3\alpha\rho_v(1-\alpha)\rho_l}{\rho_m R_b}\sqrt{\frac{2(p - p_v)}{3\rho_l}}, p_v \leq p,$$



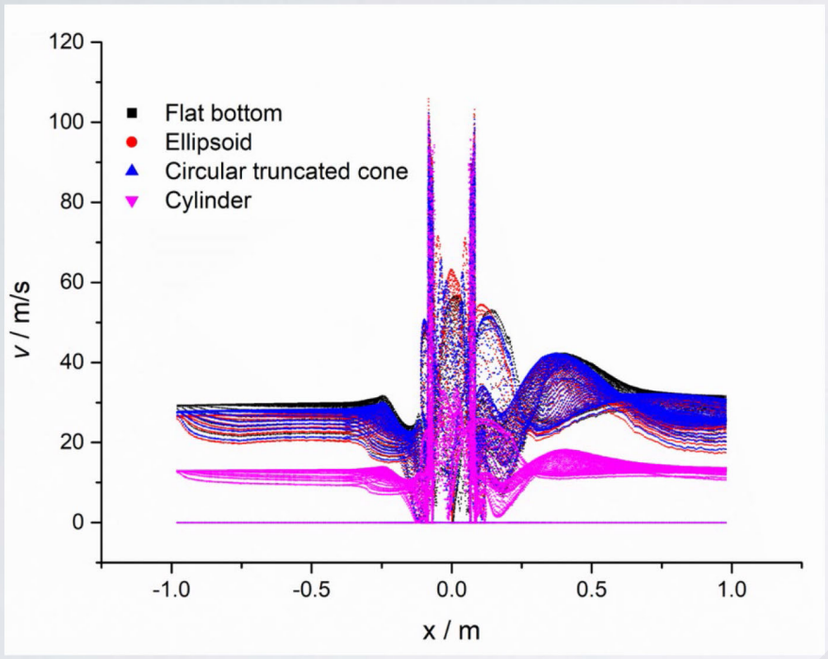
Computational model

- Non-structure mesh partition
- Pressure inlet (8.45 MPa), pressure outlet (2.0MPa)
- No slip-wall and wall function method
- Liquid water(phase 1) and water vapor (phase 2)

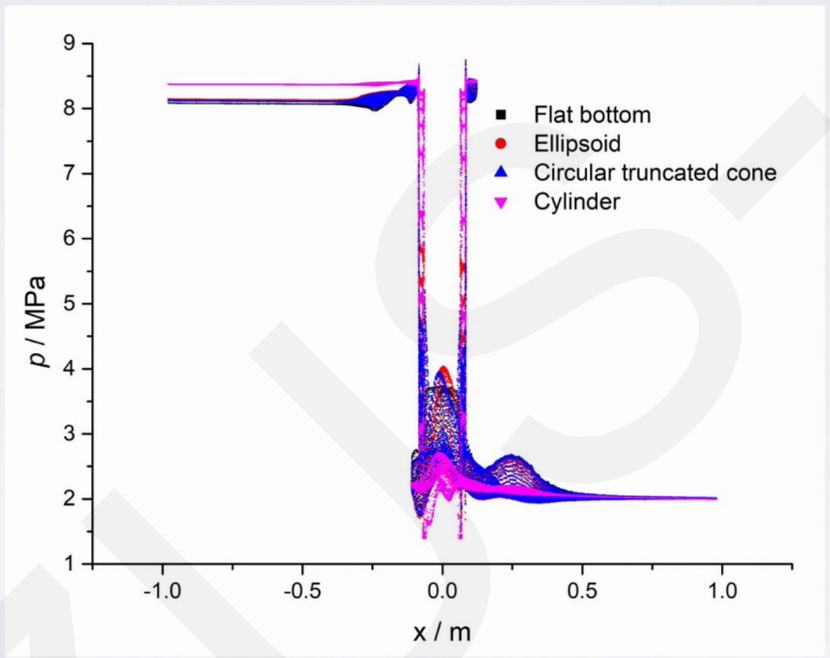


Comparisons

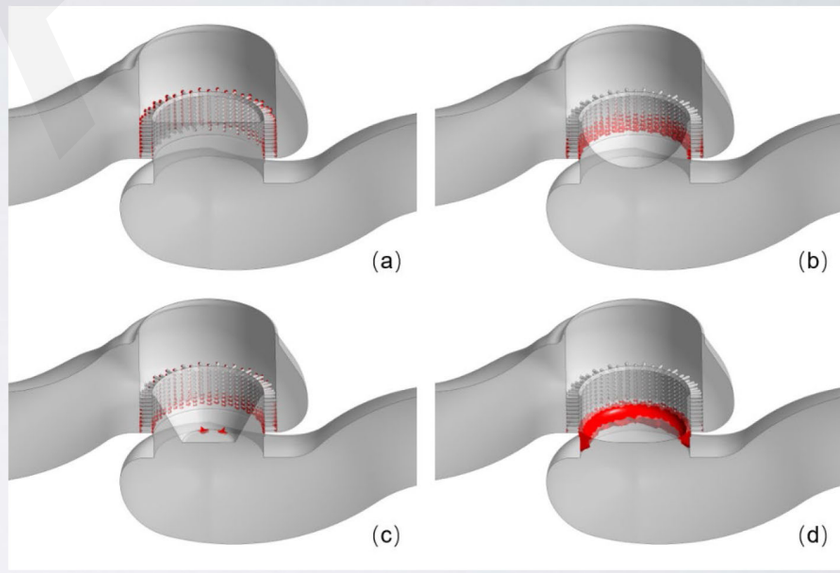
Velocity and flux

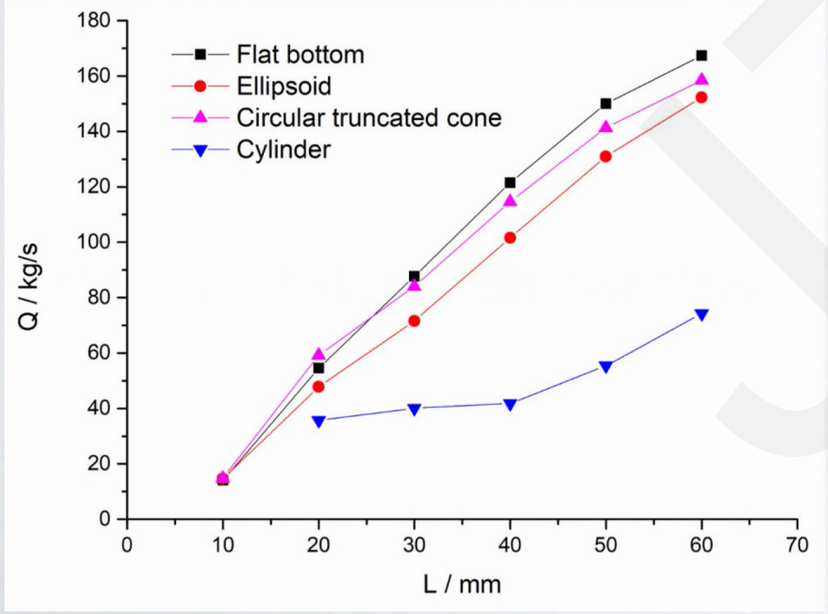


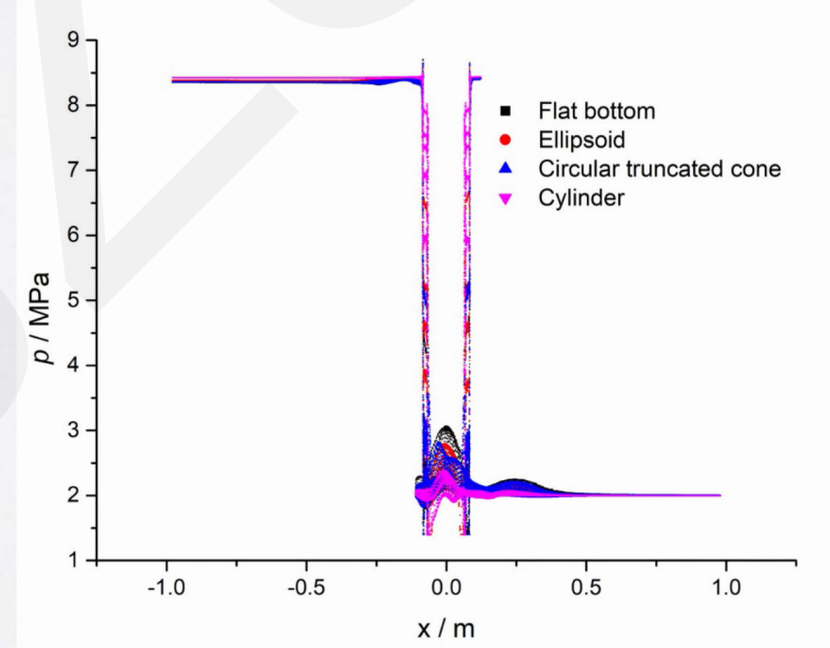
Pressure difference

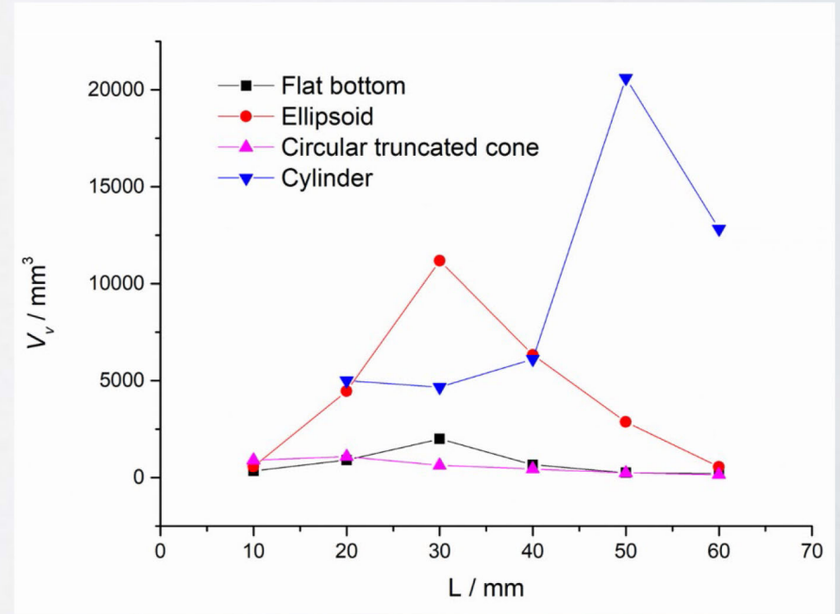


Cavitation analysis









Main conclusions

- A high-velocity region appears behind the valve throat (Sleeve) because the cross section shrinks for all four valve cores. The throttling effect for the cylinder valve core is stronger than for the other three valve cores. With the decrease of the valve core displacement, the throttling effects for all four valve cores are enhanced. The flux characteristic for the ellipsoid valve core is close to linear while the flux characteristic for the cylinder valve core is close to exponential
- For the valve core displacement of 60 mm, a pressure drop to lower than 1.5 MPa only appears in the valve with the cylinder valve core. With a decrease of the valve core displacement, a pressure drop to lower than 1.5 MPa appears in the valves with all four valve cores.
- The cavitation intensity for the ellipsoid and cylinder valve cores is more intense than the cavitation intensity for the other two valve cores. With the increase of the valve core displacement the total vapor volumes for all four valve core shapes first increase and then decrease.