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Solid-liquid flow characteristics and sticking-force analysis of valve-core fitting clearance

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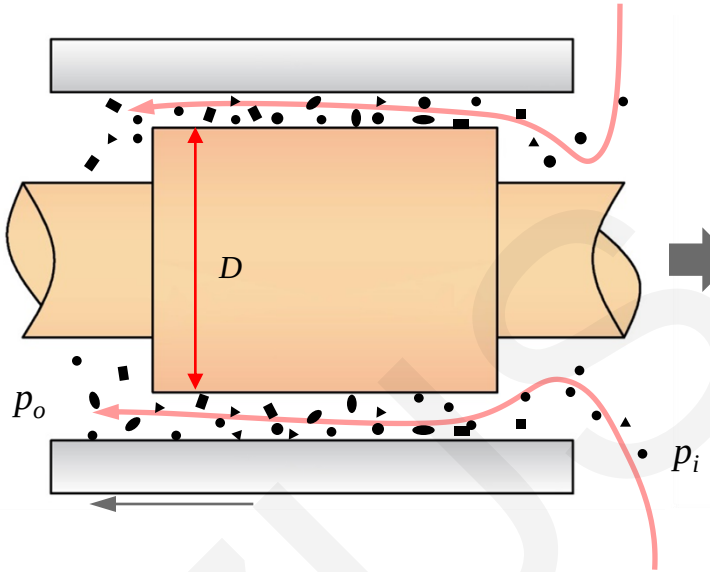
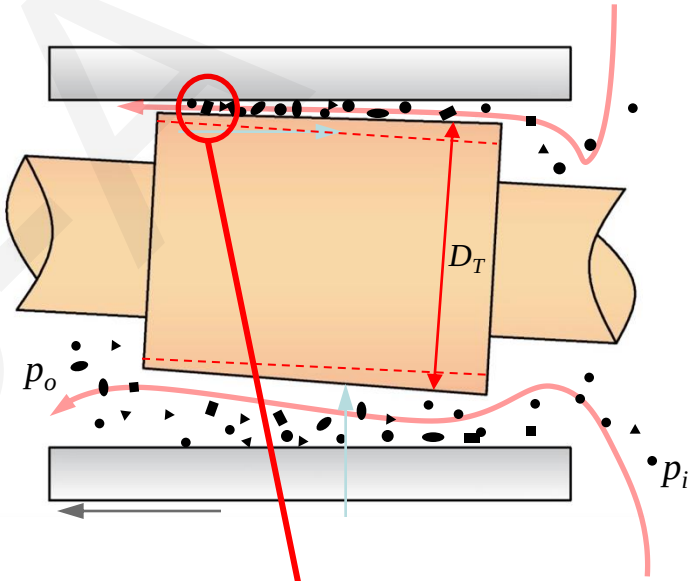
Research background

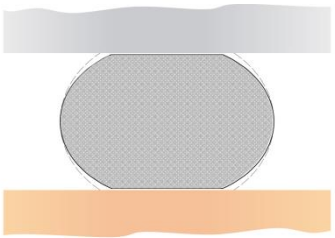
hydraulic slide valve in
Shield tunneling equipment



External contamination particles in fluid
enters the fitting clearance of the valve core

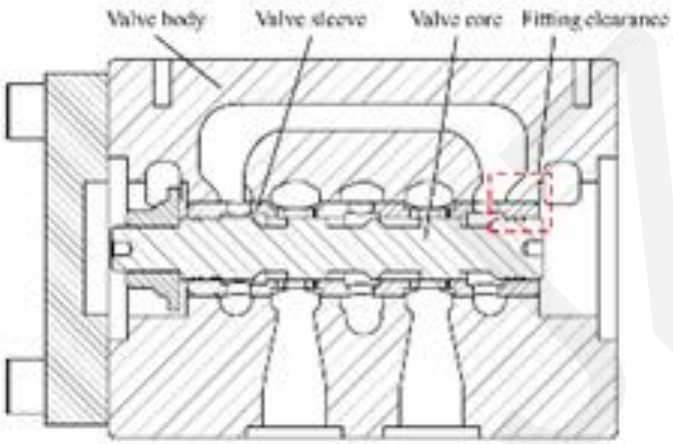


cause an increase in resistance and lead to
sticking failure of the valve core



Serious accidents

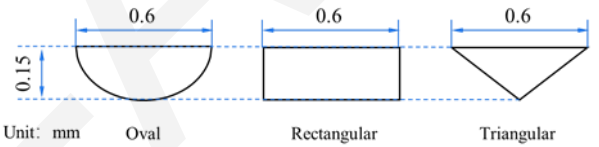
Research object and model

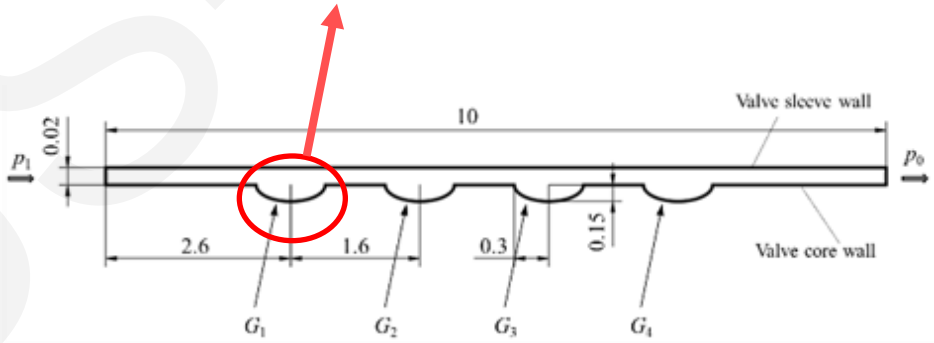


hydraulic slide valve

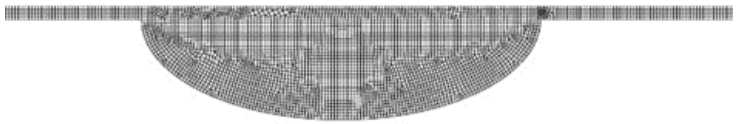
2D model

PEG

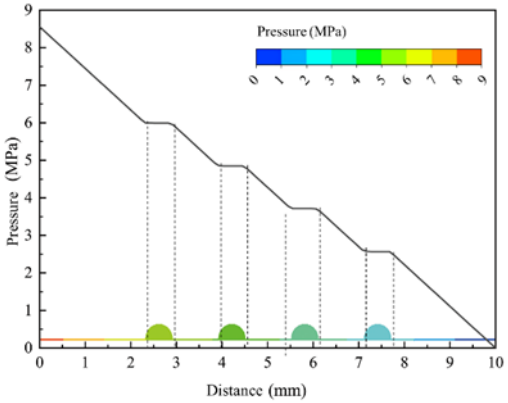




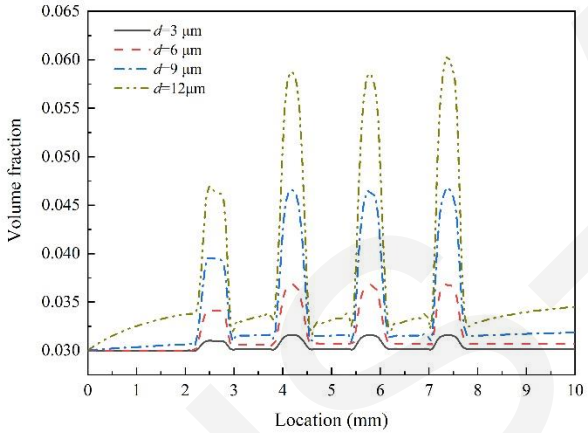
Mesh



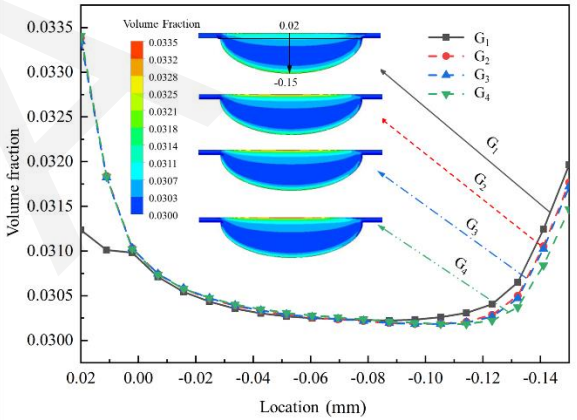
Effect of particle parameters on flow characteristics and sticking force



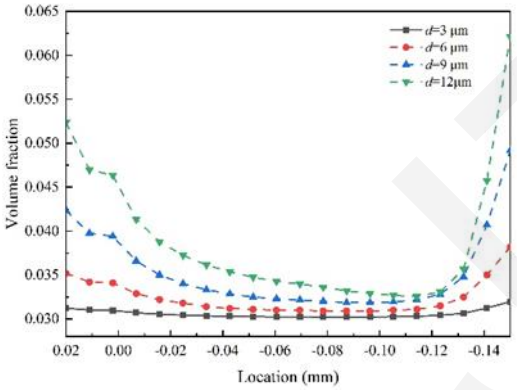
Distribution of pressure in fitting clearance



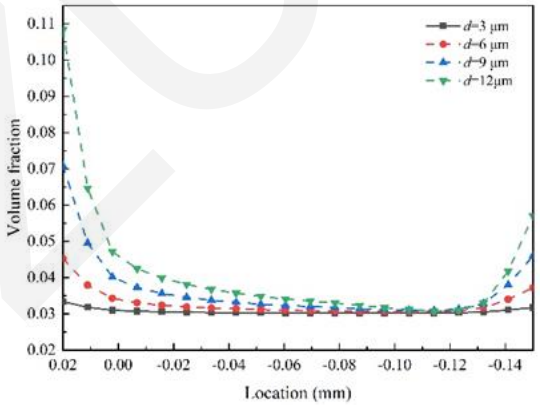
Distribution of particles in fitting clearance with different particle diameters with c=3%



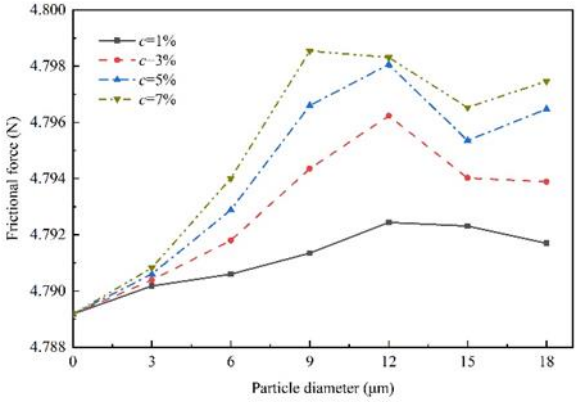
Distribution of particles in different PEGs



Distribution of particles in different PEGs(G1)



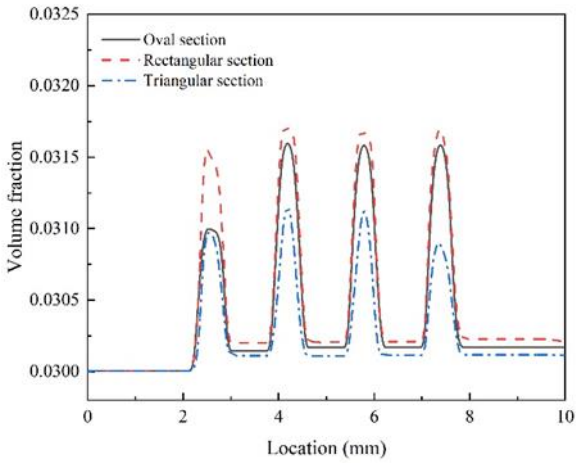
Distribution of particles in different PEGs(G2)



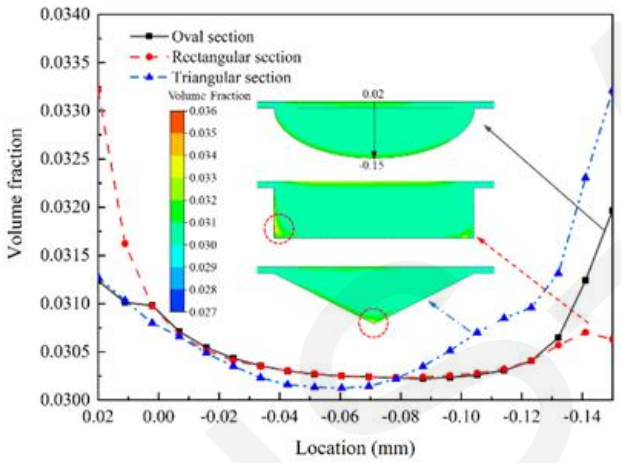
Frictional force with different particle diameters and concentrations

※ G1 means the first PEG, while G2 means the second

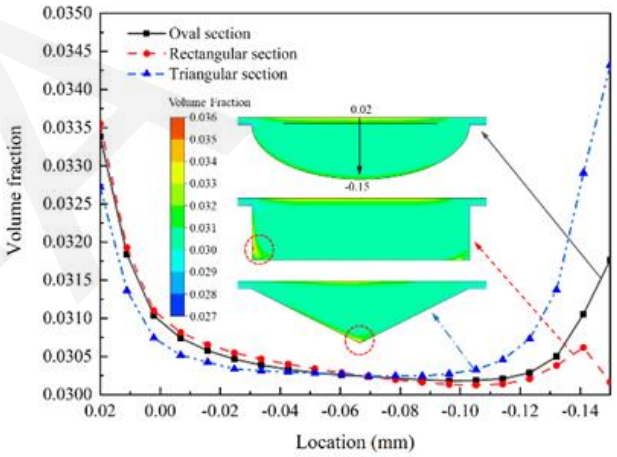
Effect of the PEG on flow characteristics and sticking force



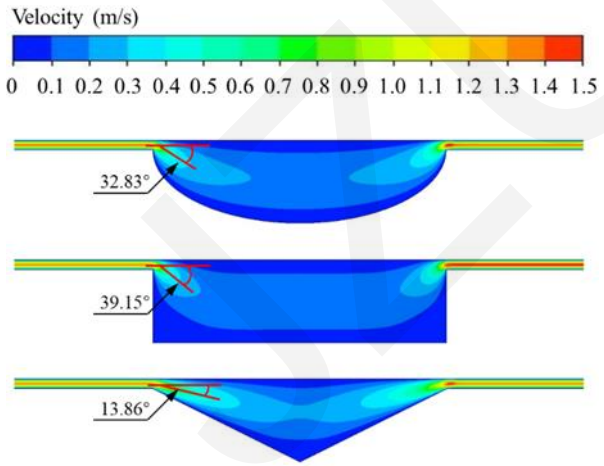
Distribution of particles in fitting clearance with different types of PEG



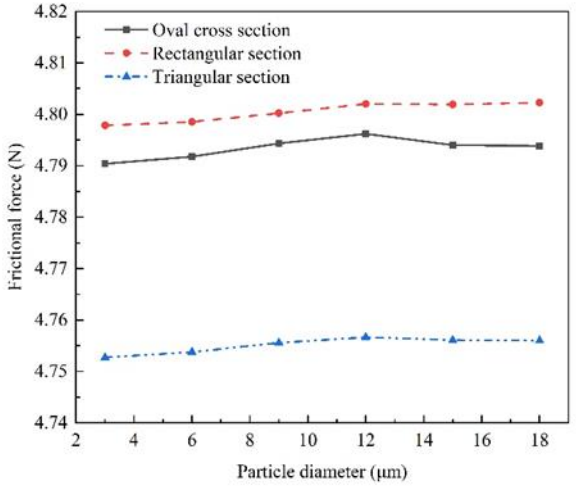
Distribution of particles with different types of PEG(G1)



Distribution of particles with different types of PEG(G2)



Distribution of velocity in fitting clearance with different types of PEG



Frictional force with different types of PEG

※ G1 means the first PEG, while G2 means the second

Conclusions

- The volume fraction of particles in the PEG is the highest, and the peak value also increases with larger particle diameter. The sticking force increases as particle concentration rises. As particle diameter grows, the sticking force first increases and then decreases.

- When the particle diameter is 12μm, the sticking force is the largest, indicating that this is the sensitive particle diameter. Thus, in the pipeline system, the appropriate scale of the filter or filter core is used to filter out particles with diameters near the sensitive particle diameter to reduce valve wear and sticking.

- The fluid-deflection angle in oval and rectangular PEGs is larger, with values of 32.83° and 39.15°, respectively. The fluid-deflection angle in a triangular PEG is relatively small, less than 50% that of an oval or rectangular PEG. The particle volume fraction is highest in a rectangular PEG, second highest in an oval PEG, and lowest in a triangular PEG, with the peaks of particle volume fraction being 0.0317, 0.0316, and 0.0312, respectively. The sticking forces for oval, rectangular, and triangular PEGs are 4.796, 4.802, and 4.757 N, respectively, when the particle diameter is 12 μm.

- A triangular PEG with a small fluid-deflection angle and strong capacity to store contamination particles at the bottom is optimal for the valve core, which alleviates the phenomenon of valve-core sticking.