Numerical study on the morphology of a liquid-liquid pintle injector element primary breakup spray

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Aims

Based on the functioning principle of pintle injector, the paper put emphasis specifically on how one radial orifice jet with different velocities impinges with the axial rectangular sheet.

The impingement morphology, the formation of spray half cone angle, the pressure distribution, the liquid diameter distribution and the liquid velocity distribution are discussed.

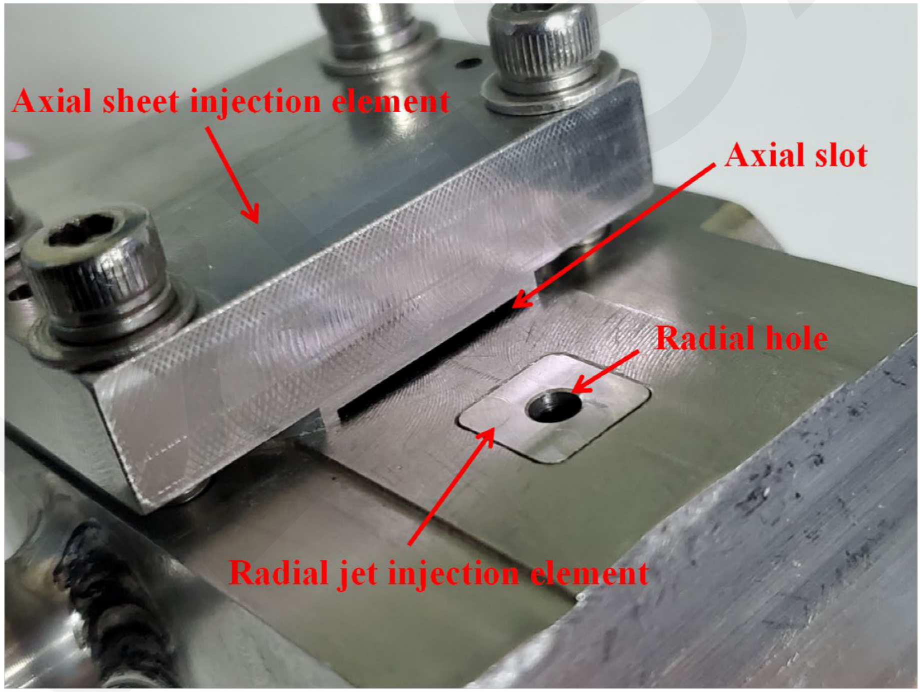

Fig 1. Test instrument model

Methods

1. VOF-to-DPM model in commercial software Ansys 19.2

2. PISO for the pressure-velocity coupling scheme

3. Geo-reconstruct for the spatial discretization

4. Adapted Mesh Refinement method

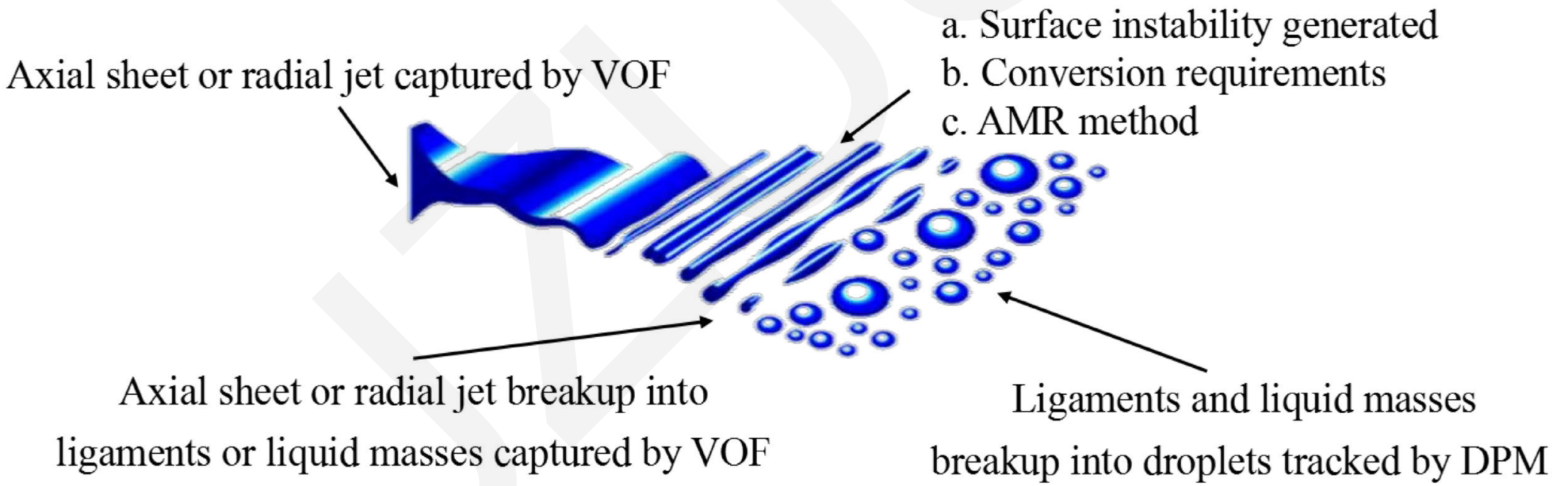

Fig.2 Illustration of the main numerical simulation mechanism

Extract Results

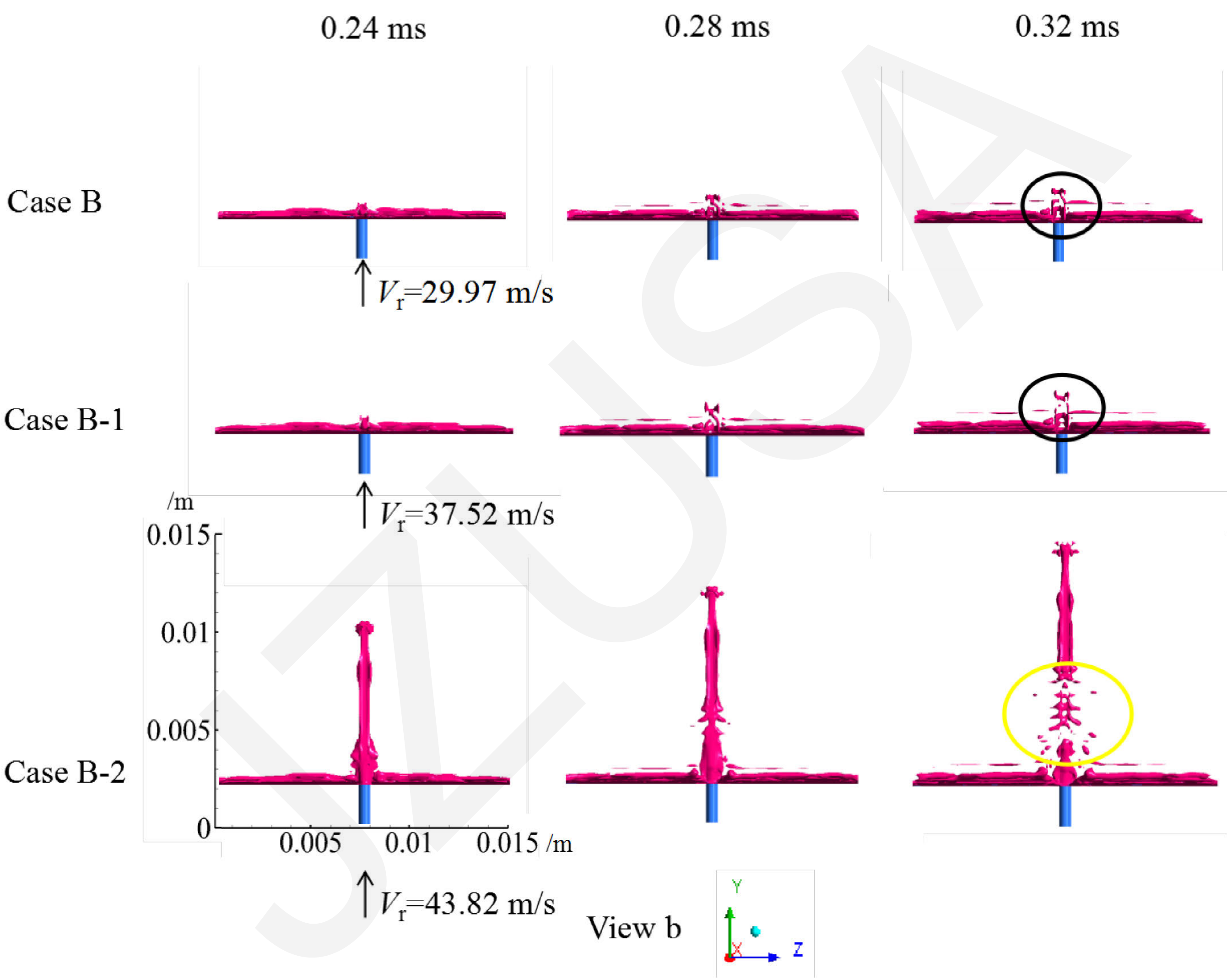

Fig.3 Impingement morphology in front view

Extract Results

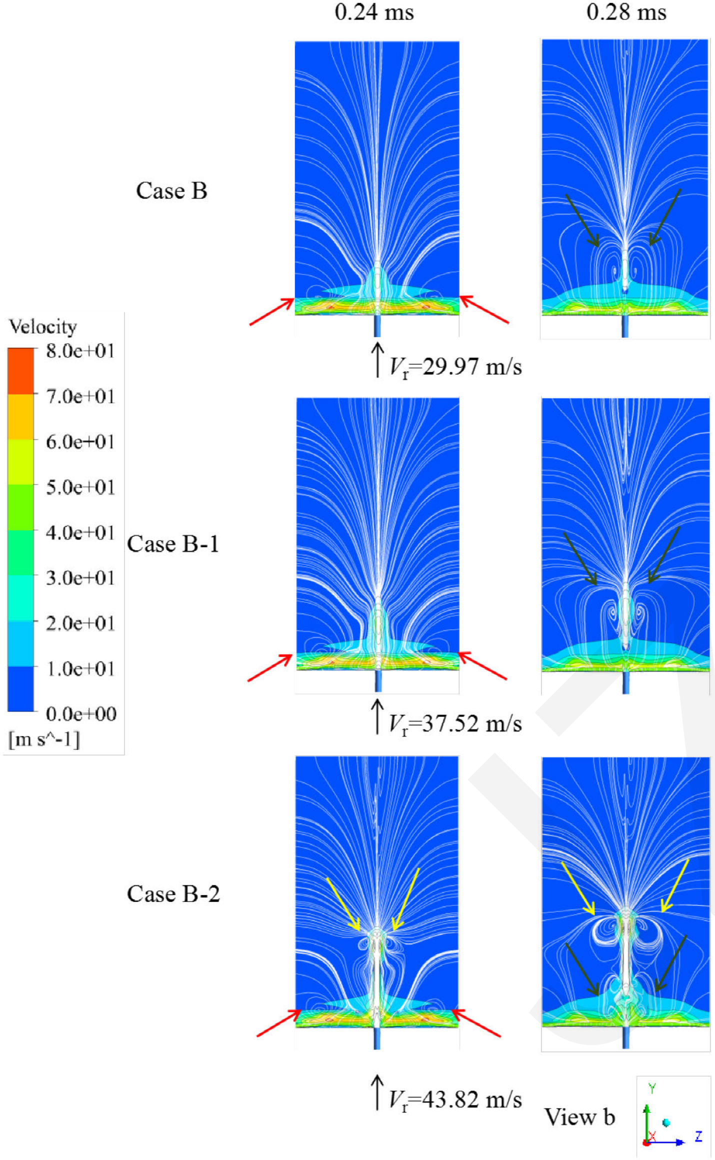

Fig.4 Formation of vortices

Extract Results

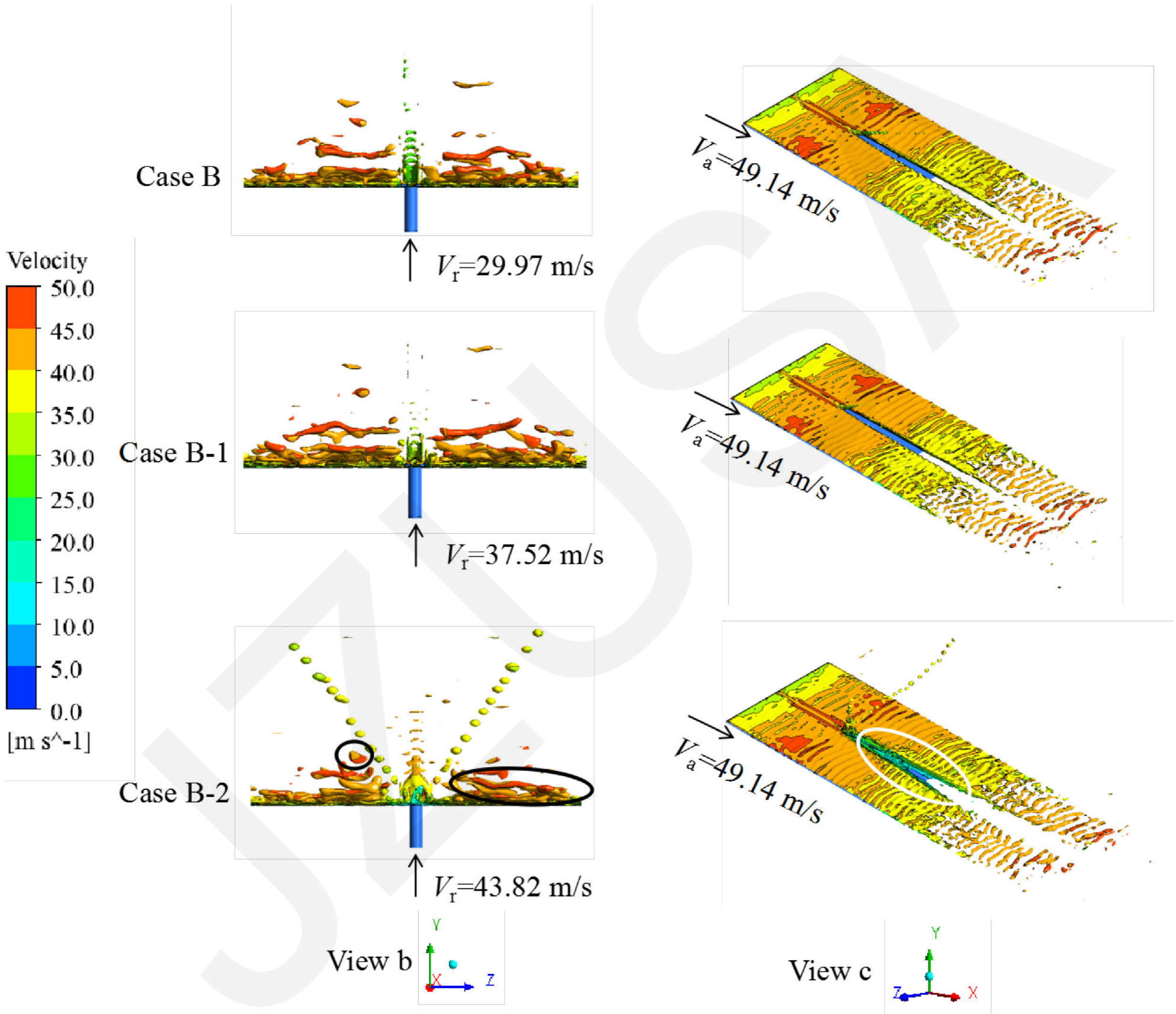

Fig.5 Lump velocity contour

Main Conclusions

1. The mushroom tip of the radial jet is captured after the penetration to the axial sheet, and disturbances generated behind the tip form vortices that aid the breakup of the tip edge.

2. The hollow structure near the impinging point is spoiled when the radial TMR is too large, and breakup into cellular ligaments happens more obviously instead.

3. The impingement process can generate new vortices near the impinging point to sustain the energy source of the breakup.

4. The spray half cone angle is proportional to the radial jet velocity.

5. A high pressure core is spotted, demonstrating the existence of a stagnation point in a liquid-liquid impinging situation.

6. Because of re-collision phenomenon, the lump diameter magnitude of the axial sheet does not decrease monotonically during the breakup process.