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SIMULATION OF MICROSCALE DROPLET FORMATION IN AEROSOL DRUG DELIVERY TECHNOLOGY USING THE FINITE VOLUME PARTICLE METHOD

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The Finite Volume Particle Method (FVPM) [1] is a novel meshless method in which particles behave like cells of the classical finite volume method, but are allowed to overlap each other. Conserved quantities are updated through the exchange of numerical flux across a rigorously defined particle interface area. The method preserves conservation, consistency, and other properties of the finite volume method, but has the advantages of smoothed particle hydrodynamics in simulation of moving boundaries and free surfaces.

In Aerogen's® aerosol drug delivery technology, a perforated plate vibrates at ultrasonic frequency under piezoelectric drive. Liquid drug stored on one side of the plate passes through the orifices to form an aerosol of microscopic droplets which can be inhaled [2]. The plate oscillates vertically with displacement $y = -A \sin(2\pi f t)$. The Reynolds number based on the aperture exit diameter D and the maximum oscillation velocity $2\pi Af$, where A and f are amplitude and frequency respectively, is 8. Dimensionless amplitude A/D is 0.625. Sample results are shown in Figure 1. Jet flow through the orifice is driven by pressurization of the reservoir due to upward acceleration of the plate during downward displacement ($0<tf<0.5$). Jet detachment, leading to droplet break-off, occurs around maximum upward displacement ($t^*=tf\cong 0.75$). The droplet develops a mushroom shape which is due to the exchange of momentum between high-velocity particles and particles with lower velocity that left it sooner. Because of the Lagrangian method, the free surface is sharply resolved without diffusion. Work is now underway to add surface tension to the model.

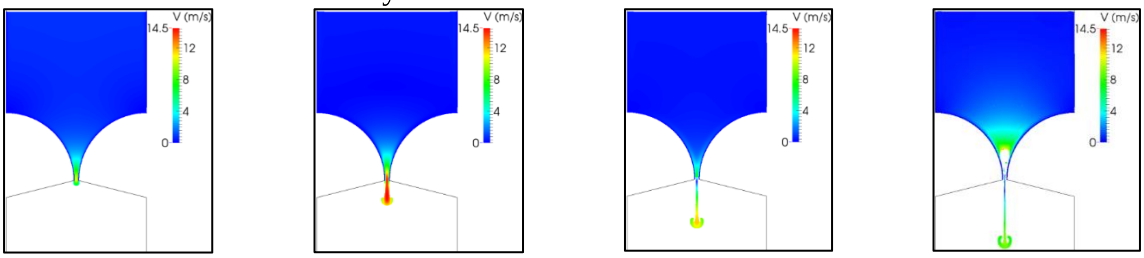

Figure 1: Velocity distribution for dimensionless time $t^* = tf = 0.25, 0.5, 0.75$, and 1 (from left to right).

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