Flow Focusing Droplet Generation Using Linear Vibration

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Introduction:

Droplet generation using flow focusing mechanism has a wide range of applications in drug delivery, ultrasound contrast agent, and the food industry. In flow focusing, when two side flows reach an orifice, the central flow is narrowed and a jet-like flow is formed. If the side flows are tuned carefully, then the central flow will start to become discrete, and tiny droplets will be generated.

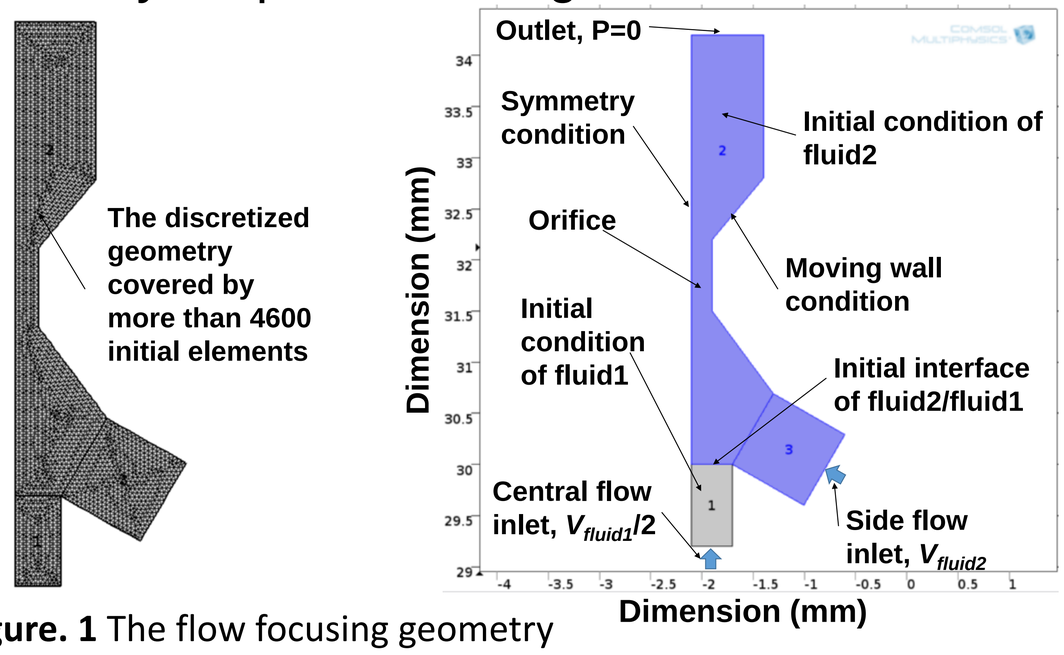

Figure. 1 The flow focusing geometry

Computational Methods:

- Laminar two-phase flow with level set method was employed;
- Fluid1 (ρ=1.1 kg/m^3, η=2 μPa.s) as the central flow, and fluid2 (ρ=1000 kg/m^3, η=0.03 Pa.s) as the side flows with the fluid1/fluid2 surface tension of 0.001 N/m were used;
- Incompressible fluids were assumed;
- Vibration was modeled using moving wall condition with triangle functions;
- To avoid transient effects, 4 vibration cycles were modeled.

Results:

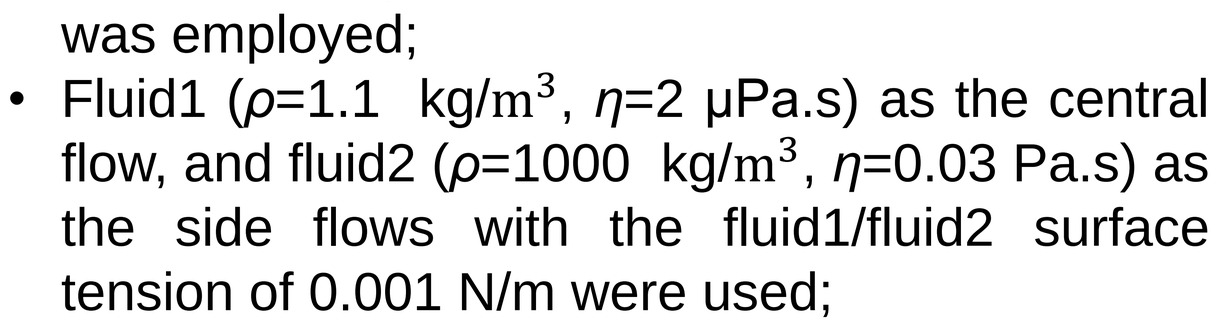

Figure. 2 One shot (at t=0.045 s) of the microchannel configuration with 5° between central and side channels; vibration frequency and amplitude, and side flow velocity were kept constant at 60 Hz, 1 mm, and V_{fluid2}= 170 mm/s, respectively; from left to right: V_{fluid1}= 7 mm/s, 17 mm/s, 27 mm/s, 37 mm/s, 47 mm/s, 57 mm/s, 67 mm/s, 77 mm/s, 87 mm/s.

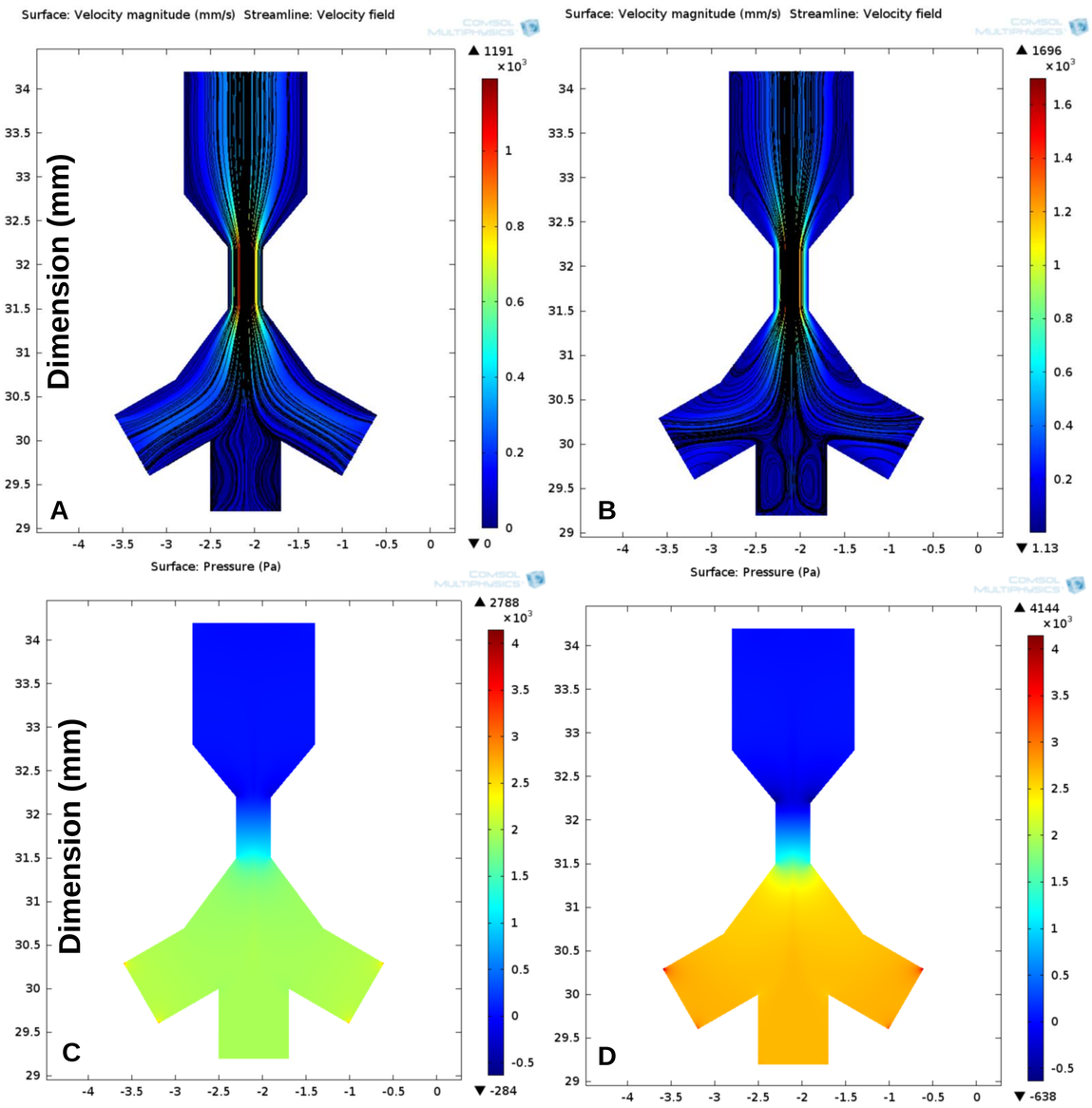

Figure. 3 (A) and (B): two shots of the velocity fields for the microchannel configuration with 60° between central and side channels; vibration frequency and amplitude, central flow velocity, and side flow velocity were kept constant at 60 Hz, 1 mm, V_{fluid1}= 87 mm/s, and V_{fluid2}= 170 mm/s, respectively; (C) and (D): two shots of pressure distribution; (A) and (C): t= 0.067 s; (B) and (D): t= 0.065 s.

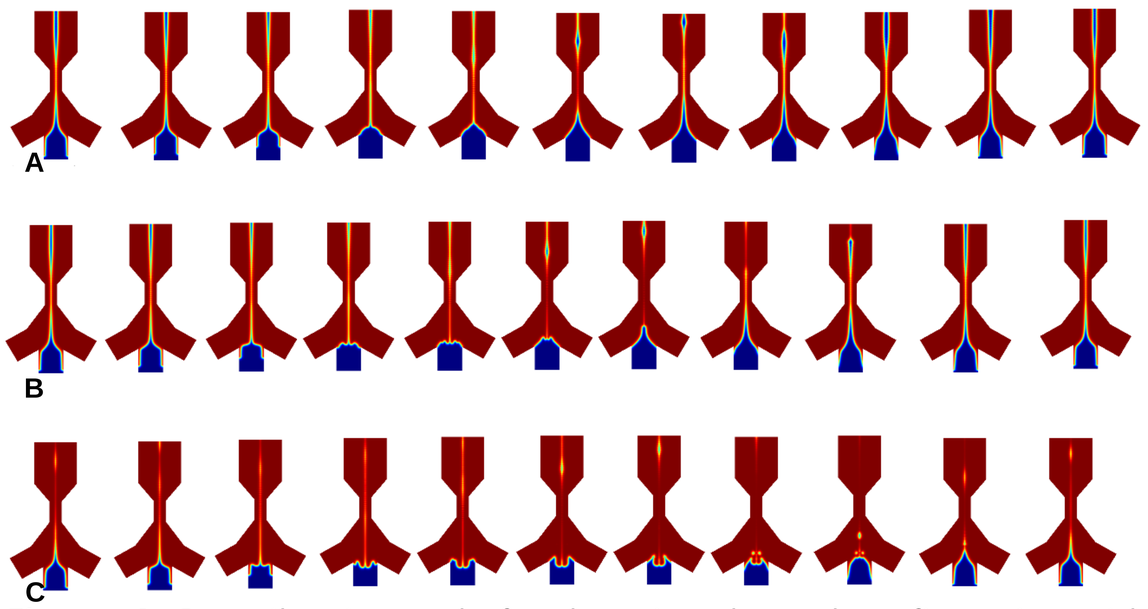

Figure. 4 One vibration cycle for the microchannel configuration with 60° between central and side flow channels; vibration frequency and amplitude, and side flow velocity were kept constant at 50 Hz, 1 mm, and V_{fluid2}= 170 mm/s, respectively; A: V_{fluid1}= 77 mm/s; B: V_{fluid1}= 47 mm/s; C: V_{fluid1}= 7 mm/s.

Conclusion:

Applying linear vibration to the flow focusing structure can dramatically affect the flow regime increasing the chance of droplet generation with desired size, if parameters such as vibration frequency, flow ratio, and orifice dimensions are chosen accurately.

References:

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