Laminar Flow of Suspensions Through Bifurcating Channels

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Suspension flows in bifurcating geometries are observed in natural and industrial settings including hydraulic fracturing, hemodynamics and microfluidics. The focus here is on flows at an asymmetric T-junction where the upstream main channel bifurcates into two daughter branches, a straight branch continuing the upstream flow, and a side branch that is orthogonal to the main and the straight channels. The flow of both single-phase fluids and non-colloidal suspensions through such geometries were investigated. Specifically, for the single-phase flows the distribution of the fluid, and for the suspension flows the distribution of the bulk suspension and individual phases among the daughter branches of known downstream pressures were measured and computed for a range of channel Reynolds numbers up to O(1000). Interactions of multiple side-channels on either side of the main channel are also considered.

Channels of square and rectangular cross sections with lengths of 10-20 centimeters and widths of 2-5 millimeters were used. Single-phase flow experiments were conducted with Newtonian fluids and with shear-thinning guar polymer solutions, while neutrally-buoyant suspensions in Newtonian fluids of matching densities were studied for particle volume fractions from 0.05 to 0.40, which includes conditions leading to jamming. The effect of particle fraction and the ratio of particle size to channel width on the distribution of phases among the branches were investigated. Experimental results are compared with computational predictions of the flow by two approaches: discrete-particle simulation and bulk mixture flow modeling.