INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Numerical simulation of suspension transport in bifurcating and wavy channels.

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SHORT ABSTRACT

This thesis deals with the numerical investigation of the shear-induced particle migration of neutrally buoyant suspensions in bifurcating channels and wavy channels via continuum via computational fluid dynamics (CFD) simulations. The CFD simulations based on continuum models such as diffusive flux model (DFM) and suspension balance model (SBM) have an advantage over the computationally intensive particle tracking simulations as they can be generalized for complex geometries. The suspension considered in our simulations was non-colloidal, and non-Brownian rigid particles in a stokes regime (Re <<1).

Numerical simulations of monodispersed suspension in a 3D oblique bifurcating channel were performed to study the concentration and velocity profiles before and after bifurcation. Both DFM and SBM were considered in the simulations and compared quantitatively. The effect of bifurcation angle on the velocity, particle concentration, and partitioning of bulk flow and particles in the downstream branches has been carried out. The suspension fluid velocity profiles showed a marked difference over pure carrier fluid velocity profiles and greatly depends on the orientation of the geometry (bifurcation angle). After the bifurcation, the velocity and concentration profiles become asymmetric and degree of asymmetry depends on the bifurcation angle. As the bifurcation angle increases, the dividing streamline shifts towards the side branch and suspension shows slightly different behavior over pure carrier fluid. The partitioning of the particles does not follow the fluid partitioning. The findings of DFM and SBM were very similar.

We have studied the effect of carrier fluid rheology on the shear-induced particle migration through 3D asymmetric T-shaped bifurcating channels. The carrier fluid was considered to be non-Newtonian inelastic fluid. Diffusive flux model of shear-induced migration in conjugation with the power-law and Bird-Carreau constitutive model for the carrier fluid was used in the simulations. The velocity and particle concentration profiles in non-Newtonian suspending fluid showed marked differences compared to that in the Newtonian carrier. Enhanced migration was observed in the case of shear-thinning fluid while low for shear thickening. The symmetric velocity and concentration profiles in the inlet branch become asymmetric in the daughter

branches and the degree of asymmetry strongly depends on the carrier fluid rheology. The results showed that the particle partitioning between daughter branches do not follow the fluid partitioning and the degree of separation depends on the relative volumetric flow rate of bulk suspension in the daughter branches. Higher separation efficiency was achieved for suspension in shear-thinning fluid and relatively lower in Newtonian and shear-thickening fluids.

Numerical simulations of bidisperse suspension flowing through symmetric T-shape bifurcating channels in converging as well as diverging flow conditions were performed. The difference in the migration flux of two species leads to size segregation, and this causes alteration of velocity and concentration profiles in the downstream locations of confluence or bifurcation. The velocity and concentration profiles for bidispersed suspension are compared with that of monodispersed case. The effect of particle size ratio and concentration of individual species on the size segregation is investigated. Depending upon the particle size ratio and species concentration, one or both species enriched the channel center. For a suspension comprised of an equal concentration of both species, larger particles always enriched the channel center. On the other hand, the position of concentration peak for smaller particles strongly depends on the size ratio. The segregation behavior in the parent as well as daughter branches of the bifurcating channels were observed to be influenced by the particle size ratios.

The numerical simulations applied to investigate the effects of concentrated suspension flow in a wavy passage shows that the solid particles migrate from regions of high shear-rate to low shear-rate with low velocities and this phenomenon is strongly influenced by particle concentration.