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International Conference on

Nanomaterials and Nanotechnology

October 29-30, 2018 | London, UK

Population balance modeling for polydisperse fluid-nanoparticle flows

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Polydisperse fluid–particle flows arise in many technological and environmental application including but not limited to aggregation, ocean spray, flocculation in water treatment, bubble dynamics in fluids, aerosol dynamical processes in both chemical engineering and air pollution. Contrary to monodisperse fluid-particle flows, the principal feature of these flows is size (or chemical composition, etc.) distribution of particles, which leads to the different coupling characteristics between particles and fluid. The numerical simulation of the polydisperse fluid-particle flows is challenging due to the polydisperse nature. To characterize the effect of polydispersity on dynamics of fluid-particle flow, the mesoscale modeling approach based on the Smoluchowski mean-field theory is preferred. The key of the modeling approach is to establish a transported population balance equation (PBE) having many phase-space variables to describe the particle size distribution, particle velocity distribution etc. The direct numerical solution of the transported PBE is intractable for most applications due to the large number of independent variables. The useful alternative is to convert the PBE to transport equations in terms of the moments of the number density function. However, the moment transport equations are not closed. In this work, a Taylor-series expansion method of moments (TEMOM) is applied to achieve the closure of moment transport equations. The emphasis will be placed on several key issues relevant to this method when coupled it to Navier-Stokes equation. The possible direction for the development of this method and its advantages and shortcomings are also discussed

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