Toward Simulation-Based Design of Particle Handling Processes

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Particulate processes pervade the petroleum, chemical, mining, pharmaceutical, and agricultural industries. Many of these processes have significant opportunities for optimization and productivity enhancements. Reliable particle modeling and simulation tools can improve critical understanding and design of particle transport processes; this talk will provide several examples in this regard. A recent approach to modeling particle flow employs the discrete element method (DEM). In DEM, the dynamics of individual powder particles are described rather than treating the particle phase as a continuum via computational fluid dynamics (CFD). DEM is especially useful for investigating phenomena occurring at the particle-length scale. This presentation will focus on DEM modeling of complex particulate flows for particle mixtures with and without surface moisture, as well as rigid and flexible non-spherical particles. These DEM simulations are validated via experiments - shear cells testing, hopper discharge, particle packing, and particle breakage. DEM simulations are also capable of developing constitutive relations for the particle phase that are needed for continuum-based CFD simulations in order to simulate large-scale processes. This talk will outline the development of constitutive models for the collisional dissipation rate and the particle-phase stress in granular kinetic theory for particle assemblies that are not spherical or monodisperse.

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Jennifer Sinclair Curtis is Distinguished Professor of Chemical Engineering and Dean of the College of Engineering at University of California, Davis. She is a Fellow of AAAS, AIChE and ASEE. Professor Curtis is a recipient of a Fulbright Senior Research Scholar Award, the CACHE Award for Excellence in Computing in Chemical Engineering Education, AIChE's Thomas-Baron Award in Fluid-Particle Systems, the AIChE's Fluidization Lectureship Award, AIChE's van Antwerpen Award, the American Society of Engineering Education's Chemical Engineering Lectureship Award, the Eminent Overseas Lectureship Award by the Institution of Engineers in Australia, and ASEE's Sharon Keillor Award for Women in Engineering, and the NSF Presidential Young Investigator Award. She has served on the National Academy of Engineering's Committee on Engineering Education and has participated in two NAE Frontiers of Research Symposia (2003 and 2008). Professor Curtis received a B.S. in Chemical Engineering from Purdue University (1983) and a PhD in Chemical Engineering from Princeton University (1989). Prior to joining UC Davis in 2015, she was Distinguished Professor of Chemical Engineering and Associate Dean for Research at the University of Florida. She has also served on the faculty of Carnegie Mellon University and Purdue University. At CMU she received the engineering college's Ladd Research Award, and at Purdue she was named University Faculty Scholar.

Professor Curtis' research focuses on the development of multiphase CFD models and discrete element method models for particulate flow. Her work has been applied to improve the design and optimization of chemical, energy, mining, pharmaceutical, and agricultural processes in which particulate processes are pervasive. Her multiphase flow models, based on first principles granular kinetic theory, have been adopted by the software package ANSYS Fluent, the largest producer of simulation software used by 96 of the 100 biggest industrial companies and over 40,000 customers. Her multiphase flow models are also included in the CFD Research Corporation's multiphase flow CFD software package and the open-source CFD code (OpenFOAM).