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GRANULAR AND MULTIPHASE FLOWS

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Constitutive Modeling of Dense Granular Flows

Slow flows of dense granular materials are encountered in a wide variety of industrial processing devices, such as fluidized beds and hoppers. Predictive continuum modeling of such flows is important in designing the devices on a firm numerical basis instead of on empirical trial-and-error approaches. However, reliable constitutive models for the rheological behaviors of dense granular flows that are linked to particle-level properties are not available for general flow conditions. In this presentation, our efforts aimed at constructing such constitutive models using a hierarchical multiscale approach will be presented.

In this multiscale approach, the discrete element method is used to simulate the motion of individual particles in sheared assemblies; the stress and kinematics information at the continuum level are then obtained through statistical averaging. The continuum information is then used to establish quantitative closure relations for two types of continuum rheological models – an order-zero model by Schaeffer (*Journal of Differential Equations. 1987. 66, 19*) and a hypoplastic model (*Mechanics of Material. 1996. 23, 45*).

In this presentation, rheological behaviors of nearly homogeneous assemblies of uniformly sized, spherical particles in periodic domains under steady and unsteady simple shear will be presented. These results will be compared with predictions of the above two continuum constitutive models, supplemented with the closures determined in this study.

***** Work with Professor Sankaran Sundaresan in the Department of Chemical Engineering of Princeton University.

Jin Sun is currently a postdoctoral fellow in the Department of Chemical Engineering at Princeton University. Dr. Sun earned his Ph.D. degree in Mechanical Engineering from Iowa State University in 2007 and obtained his B.S. in Mechanical Engineering *cum laude* from Dalian University of Science and Technology in China. He was awarded the Research Excellence Award, a top honor for Ph.D. degree recipients at Iowa State University, and elected to Tau Beta Pi during his graduate study. He has been conducting computational studies of granular and multiphase flows using discrete and continuum methods, with applications in predicting particle mixing and segregation in fluidized beds. Part of his research findings has been published as six papers in peer-viewed journals. As an active member of the American Society of Mechanical Engineers (ASME) and the American Physical Society (APS), Dr. Sun is organizing a technical session for the 2008 ASME International Mechanical Engineering Congress and Exposition.

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