FLUIDIZATION OF IRREGULAR PARTICLES - PART I: A DISCRETE ELEMENT METHOD TO MODEL COLLISIONS BETWEEN NON-CONVEX PARTICLES

Andriarimina Daniel Rakotonirina, Fluid Mechanics Department, IFP Energies Nouvelles, Rond-point de l'Echangeur de Solaize, BP 3, 69360 Solaize, France
andriarimina-daniel.rakotonirina@ifp.fr
Anthony Wachs, Departments of Mathematics and Chemical & Biological Engineering,University of British Columbia, Vancouver, BC, Canada
Jean-Yves Delenne, French National Institute for Agricultural Research, IATE Group,2 place Pierre Viala, 34060 Montpellier, France
Farhang Radjai, University Montpellier 2, CNRS, LMGC UMR 5508, Place Eugène Bataillon,F-34095 Montpellier Cedex, France

The flow dynamics of a fluidized bed can be very complicated. As the solid volume fraction is generally high, particle-particle collisions cannot be ignored. Many studies in the literature deal with perfectly spherical particles while very few deal with non-spherical ones and even less with angular or non-convex particles. However, these irregularly shaped particles are not uncommon in chemical engineering. Among others, Escudié *et al* (1) showed that the particle shape influences markedly the dynamics of such a system. We suggest an accurate and efficient way to model collisions between particles of (almost) arbitrary shape, that can be integrated into a comprehensive modeling of a fluidized bed. For that purpose, we develop a Discrete Element Method (DEM) combined with a soft particle contact model that treats the contact between bodies of various shape and size (2). In particular, for non-convex bodies, our strategy is based on decomposing a non-convex body into a set of convex ones (3). Therefore, our novel method can be called “glued convex method”, as an extension of the popular “glued-spheres” method (4). It hence uses all the features involved in DEM simulations of convex bodies, such as the contact detection strategy based on a Gilbert-Johnson-Keerthi algorithm (5) and the linked-cell spatial sorting which accelerates the contact resolution (6). The problem of multiple contact requires a particular attention (4,7). The method is implemented in our granular dynamics code Grains3D. As an illustration of the powerful modelling capabilities of Grains3D, we show results of simulation of settling non-convex catalytic pellets in a cylindrical chemical reactor.

REFERENCES

1. R. Escudié, N. Epstein, J.R. Grace, H.T. Bi, Effect of particle shape on liquid-fluidized beds of binary (and ternary) solids mixtures: segregation vs. mixing. Chemical Engineering Science, 61(5): 1528, 2006.
2. A. Wachs, L. Girolami, G. Vinay, and G. Ferrer. Grains3D, a flexible DEM approach for particles of arbitrary convex shape - Part I: Numerical model and validations. Powder Technology, 224:374-389, 2012.
3. A. D. Rakotonirina, A. Wachs, J.-Y. Delenne, F. Radjai. Grains3D, a flexible DEM approach for particles of arbitrary convex shape - Part III: extension to non convex particles, submitted to Powder Technology, 2015.
4. D. Höhner, S. Wirtz, H. Kruggel-Emden, and V. Scherer. Comparison of the multi-sphere and polyhedral approach to simulate non-spherical particles within the discrete element method: Influence on temporal force evolution for multiple contacts. Powder Technology, 208(3):643-656, 2011.
5. Elmer G. Gilbert, Daniel W. Johnson, and S. Sathiya Keerthi. A fast procedure for computing the distance between complex objects in three-dimensional space. Robotics and Automation, IEEE Journal of Robotics and Automation, 4(2):193-203, 1988.
6. Gary S. Grest, Burkhard Dünweg, and Kurt Kremer. Vectorized link cell Fortran code for molecular dynamics simulations for a large number of particles. Computer Physics Communications, 55(3):269-285, 1989.
7. H. Kruggel-Emden, S. Rickelt, S. Wirtz, and V. Scherer. A study on the validity of the multi-sphere discrete element method. Powder Technology, 188(2):153-165, 2008.