CFD-DEM simulation of fluid flow assisted mixing of binary granular beds

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Abstract

Granular mixing is an essential process for food processing, agriculture, pharmaceutical and cement processing industries. The enhanced efficiency of mixing in these systems has the potential to result in a significant reduction in the energy costs for these process industries. In this work, we study the mixing of binary granular assemblies assisted by the flow of a fluid through the assembly. Mixing characteristics of granular beds with particles of different density ratios and size ratios are analyzed. The influence of stacking order of the particles of different types on the degree of mixing is investigated.

A fully segregated three-dimensional binary granular assembly is taken in order to study the mixing characteristics. The granular system is exposed to continuous fluid flow from the bottom surface towards the top surface to achieve the required mixing [1]. The dynamics of the fluid-granular phase is simulated using the open source tool CFDEM [2]. The granular assembly is divided into a finite number of computational cells. The particle motions are calculated using the Discrete Element Method (DEM) [3] which determines the state of the granular phase in each of these cells. The state of the granular phase is communicated to the Computational Fluid Dynamics (CFD) [4] solver for solving the governing Navier-Stokes equation.

The results reveal that the degree of mixing represented by Lacey index [5] is closely related to the stacking sequence of the particles. If the lighter particles are stacked below the heavier particles, the lighter particles get displaced by the inlet fluid easily. Hence, the heavy particles at the top will move towards bottom aiding in better mixing with the lighter particles. In the case of bed with lighter particles above, the heavy particles at the bottom do not move easily offering certain resistance to mixing. Further, we also discuss the results of a parametric study depicting the influence of particle size ratio and density ratio on the mixing characteristics.

Keywords: CFD-DEM, particle mixing, binary granular bed, Lacey index, fluidized bed

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