Study on discrete element simulations for the industrial applications

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Abstract

This paper presents the DEM simulations for the industrial applications. Although the DEM seems to be an established approach, there are some critical problems in the industrial applications. The DEM has been mainly applied to small and simple systems so far. In other words, the DEM has not been applied to actually industrial systems, where the vessel shape is complex, number of particles is over billion and complex gas-solid-liquid flows. Therefore the existing DEM has problem about the industrial applications. In order to solve this problem, the author's group developed some advanced models [1]. The signed distance function [2] based wall boundary model was developed to perform a DEM simulation of a granular flow in an arbitrary shaped vessel. The SDF made revolution in the DEM simulations because an arbitrary shape wall can be created without complex operations. All we have to do is set the distance from wall and inside/outside of the calculation domain. Applicability of the SDF to industrial DEM simulations was proven in a twin-screw kneader [3], ribbon mixer [4], die filling [5], etc. The coarse grain model [6] was developed to simulate a large-scale DEM simulation with low calculation cost. The coarse grain model is a scaling law model of the DEM, and hence large-sized model particle is used instead of group of the original particles. Adequacy of the coarse grain model was shown in pneumatic conveying system [6], fluidized beds [7], etc. The DEM-VOF method [8] was developed to perform a simulation of a gas-solid-liquid three-phase flow. In this method, THINC/WLIC was employed to capture the free surface fluid flow, and local volume average technique was introduced in the governing equations. When the arbitrary shape of the wall should be modeled, the immersed boundary method is applied. Applicability of the DEM-VOF was shown in a wet ball mill, a twin-screw kneader, etc.

Consequently, the author's group develops strong DEM technologies as the industrial applications. At present, the author's group performs simulations for various industrial systems by combing the above technologies.

Keywords:

Signed distance function (SDF) based wall boundary; Coarse grain model of the DEM; DEM-MPS method; DEM-VOF method

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