A discrete element-material point coupling method for impact with multiple particles

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Abstract

Typical multiple-particle impact problem, such as cold spraying, shot peening, and landmine explosion, attract great interests in both scientific research and engineering practice. The interactions between particles and between the particle and the target are complex and lead to large deformation and plasticity. Single traditional mesh-based method may encounter difficulties in dealing with large number of contacts in addition to the mesh distortion difficulty induced by intensive impact loading.

The discrete element method (DEM) and the material point method (MPM) are two kinds of methods receiving much attention. A group of rigid elements are used in the DEM, and these elements interact according to prescribed interaction law. So DEM is very appropriate for simulating systems consisting of large number of particles. One group of Lagrangian points and one set of Eulerian background mesh are used in the MPM. The deformation of an object is represented with the points, and the background mesh provides the approximation and serves to solve momentum equations. The MPM is very effective and efficient in solving large deformation problems.

In this work, a DEM-MPM coupling method is developed for the multiple-particle impact process. The particles are modeled with the DEM, and the target is simulated with the MPM. The interactions between discrete elements and material points are accomplished through the contact algorithm based on penalty scheme. Several examples are designed to validate the proposed method. And the coupling method is used to simulate the impact of sand driven by explosion on the clamped plate, and the numerical results and the experimental results agree very well.

Keywords: Discrete element method, material point method, multiple-particle impact, coupling method

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