Impact force analysis with the nonsmooth discrete element method

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ABSTRACT

Analysis of impact forces is applicable for predicting particle breakage and equipment wear in systems for transportation and storage of granular materials, such as iron ore pellets [1,2]. The nonsmooth discrete element method (NDEM) [3,4] can be understood as a time-implicit version of the conventional, or smooth, discrete element method (DEM). The NDEM enable large time-step integration by allowing the velocities to change discontinuously in accordance with an imposed contact and impact law, expressed in terms of inequality and complementarity conditions, in addition to the rigid body equations of motion. In some applications this shorten the simulation time by several orders in magnitude [4] and thus enable quick design experiments and systematic exploration of the design and parameter space. An apparent deficiency with the NDEM is that the force that occur due to high-velocity impacts is not explicitly computed. Instead, the NDEM solver compute the net impulse that is necessary for fulfilling the imposed contact and impact law. The conditions for particle breakage and surface wear are directly dependent on the contact force and not the impulse.

A method is presented for a posteriori computation of the impact contact forces from NDEM impulses. For pair-wise contacts, the equivalent contact force can be deduced from the impulse by assuming the Hertz contact law [5]. This is extended to more complex contact networks, with simultaneous impacts, and validated using smooth DEM simulation. The method is demonstrated by studying systems are representative for transportation and storage of granular materials and analysing the statistical distribution of impact forces and energy dissipation, thus indicating breakage and wear.

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