Dynamic plasticity in metals computed by a discrete element method

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Abstract

Since their first use by Hoover et al (1974) in models for crystalline materials and Cundall & Strack (1979) in geotechnical problems, Discrete Elements methods (DEM) have found a large field of application in granular materials, soil and rock mechanics. The handling of a set of particles interacting by means of forces and torques allows a variety of models for the expression of these bonds and for the material's behaviour.

In the Mka3D code, the authors [2] have been able to simulate the deformation and fragmentation of a three-dimensional linear elastic brittle material. The discretisation is achieved through rigid convex polyhedral particles. The forces and torques are computed directly through macroscopic quantities like the distance and relative rotation between two particles.

The aim of this presentation is to introduce an extension of this formalism with the goal to compute isothermal dynamic plasticity and fragmentation in metals. The visco-plastic behaviours considered are for instance the Johnson-Cook [1] model.

Several difficulties had to be dealt with. First, plastic forces are non-conservative and thus cannot be computed by derivation of a potential energy as was the case in [2]. Second, metals have an incompressible plastic behaviour which had to be incorporated into the formalism of [2].

References

[1] G.R. Johnson and W.H. Cook. A constitutive model and data for metals subjected to large strains; high strain rates and high temperatures. 1983.

[2] L. Monasse and C. Mariotti. An energy-preserving discrete element method for elastodynamics. *ESAIM: Mathematical Modelling and Numerical Analysis*, 46:1527–1553, 2012.