The Development of the MPM for Better Simulating Nonlocal Failure

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Abstract

The evolution of interfacial failure between different materials has the nonlocal feature [Chen and Schreyer, 1994; among others], namely, the stress state at a material point depends on the strain distribution around that point in a representative volume of certain size. To better simulate the multi-material interactions, the material point method (MPM) has evolved over the last two and a half decades, and been applied to many areas of Simulation-based Engineering Science, as shown in the recent comprehensive review [Zhang et al., 2016]. For better treating large deformation problems, efforts have been made very recently to enhance the MPM with B-spline basis functions [Gan et al., 2018], and time-discontinuous mapping operation [Lu et al., 2018]. Based on the conservation laws of mass, momentum and energy, the generalized interpolation material point (GIMP) method has also been improved for simulating and evaluating the fully coupled thermomechanical responses, such as the failure evolution in a snowy slope [Tao et al., 2018]. The fully coupled thermomechanical GIMP method (CTGIMP) considers the effects of both the temperature on deformation and the deformation on temperature so that the additive manufacturing process might be better evaluated with high fidelity. However, the CTGIMP remains to be validated against experimental data. Since each spatial discretization procedure has its own strength and limitation, a robust model-based simulation tool for multiscale and multiphysics problems should take advantage of the strengths of different procedures for different problem domains. We are developing the smoothed MPM by integrating the strengths of smoothed particle hydrodynamics (SPH) and MPM to better handle the impact problems, in which the smoothed MPM mapping operation is employed only around the impact surface without invoking master/slave nodes while either the MPM or SPH could be used in other parts of the problem domain [He et al., 2018]. As a result, no artificial viscosity is required to eliminate the problem-specific choice for simulating transient problems. In this conference, the recent advances in improving the MPM for better simulating nonlocal failure evolution with the nonlocal mapping operation will be presented.

Keywords: Material Point Method, Particle Methods, Nonlocal Failure, Interface

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