Nonlocal Interfacial Modeling within the MPM Framework for Transient Responses

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Multi-phase transient interactions play an important role in modern engineering applications such as additive manufacturing, drilling, hydrofracturing, impact and penetration. It has been shown that the evolution of interfacial failure between different material phases has the nonlocal feature [1], namely, the stress state at a material point depends on the strain distribution around that point in a representative volume of certain size. Hence, local constitutive models cannot predict the real physics associated with interfacial failure evolution. On the other hand, the mesh-based methods cannot describe the real physics involved in the interfacial problems, due to the use of master/slave nodes at the contact surface of assumed zero thickness in addition to re-meshing as required for the simulation of failure evolution. To better simulate the multi-phase 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 [2]. To improve the solution accuracy for large deformation cases, very recent efforts have been made to enhance the MPM with B-spline basis functions [3], and time-discontinuous mapping operation [4]. 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 [5]. Since the improvement over the original MPM is essentially to replace the local mapping and remapping process with a nonlocal one at additional computational costs, it might be feasible for us to integrate nonlocal constitutive modeling with the smoothed operator for efficient model-based simulation. In this conference, recent research results will be presented to demonstrate nonlocal interfacial modeling within the MPM framework for evaluating transient responses.

References

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