A TECHNIQUE FOR MODELING MATERIAL INTERFACES IN MULTI-MATERIAL CSM APPLICATIONS

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Realistic and accurate treatment of material interfaces is crucial to a large class of problems that involve highly dynamic CSM applications, such as vehicle crash dynamics, vulnerability and failure analysis, orbital debris simulation, and ballistic penetration. The Lagrangian finite element method is often the technique of choice for this group of problems, due to its natural ability to represent interfaces and to apply the appropriate constraints there. However, many of these applications involve deformations that are well beyond the ability of Lagrangian finite elements to model them; the finite elements can develop large aspect ratios, twist, or even invert. A variety of alternative methods have been developed in an attempt to alleviate some of these difficulties; included among these are SPH and other meshless methods, Eulerian methods, and arbitrary Lagrangian-Eulerian (ALE) methods. Eulerian and ALE methods in particular have gained popularity over the past decade.

A complication that accompanies Eulerian or ALE approaches, however, is the introduction of multi-material elements into the computation, which makes the modeling of phenomena occurring at the interface challenging. Traditionally, a series of approximations is employed aimed at replacing the contacting materials in an element by an equivalent, single material – and the approximations used often have little or nothing to do with the actual physics taking place at the contact boundary. For example, for J2-type materials the flow stress in a mixed material element is usually assumed to be a volume-weighted average of all J2 materials in that element.

In this work a technique is described for treatment of material interfaces in multimaterial CSM applications. This work differs from traditional approaches in that no mixed-element thermodynamic or constitutive models are used in the formulation. Instead, the governing equations are solved for each material, with the appropriate inequality constraints applied at intermediate locations within elements. What arises from this is a set of coupled equations that are approximated by an uncoupled, reduced form. The traction and position along the contact boundary arise naturally from this formulation. Two-dimensional numerical examples for frictionless contact are shown which illustrate the superiority of this technique when compared to traditional mixedelement methods.