Testing Multimaterial Treatment of Mixed Elements in ALEGRA

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We present a series of test problems for verifying the accuracy of the treatment of mixed elements in Multimaterial Arbitrary Lagrangian Eulerian (ALE) codes under a variety of physical conditions. A mixed element is one in which more than one material is present and the materials are assumed to occupy distinct subvolumes of the element; the location of the interfaces between materials may or may not be explicitly computed. Mixed elements arise during the remap step, or from the discretization of the initial conditions.

The deformation of an element changes the thermodynamic and stress states of the materials in the element. In ALEGRA and many other hydrocodes, mixture relations specify the distribution of the element deformation, stress and temperature to each material. The simplest mixture assumption apportions based only on the volume fractions of the materials. This can lead to aphysical material states when e.g. one material is much more compressible than another; the deformation of the stiffer material is greatly overestimated, often leading to extremely high stresses or temperatures which undermine the simulation. More complex mixture rules have been shown to produce more physically reasonable material states in some cases, but a generally satisfactory method for mixed elements remains an elusive objective.

We have developed test problems specifically to quantitatively assess different methods for treating mixed elements. These test problems feature exact solutions, enabling quantitative error analysis and code verification, but are also motivated by real-world applications. The test problems are applicable to methods which involve explicit interface tracking, as well as the mixing rules implemented in ALEGRA.

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