Simulation of Failure in UINTAH Approaches & Mesh Sensitivity
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Introduction
In the integrated simulation of an exploding container in a fire, detailed dynamic fracture mechanics calculations for each crack is computationally expensive. To reduce the cost and yet perform physically realistic simulations, we determine failed material points and convert them into a new material that interacts with the rest of the body via contact. Some results from our failure simulations are shown here.

Approach
Empirical Failure Criterion: TEPLA-F
\[
\left(\frac{f}{f_c}\right)^2 + \left(\frac{\sigma_p}{\sigma_p}\right)^2 = 1
\]
where
- \( f \): Porosity
- \( f_c \): Maximum allowable porosity
- \( \varepsilon_p \): Plastic strain
- \( \varepsilon_{p_f} \): Plastic strain at fracture

\[
f = f_{\text{initial}} + f_{\text{grow}}
\]

\[
\begin{align*}
D_0 &= D_1 + D_2 \exp\left( -\frac{\sigma}{\sigma_p} \right) \\
D_2 &= \frac{1}{1 + D_3 \tau^m} \\
D_3 &= \text{Material constants, } i = 1, 5 \\
\tau &= \text{Cauchy stress} \\
\tau^m &= \text{Homologous temperature}
\end{align*}
\]

Loss of Stability Criteria
Drucker Postulate
\[
\sigma : \mathbf{D}^p \leq 0
\]
where
- \( \sigma \): Cauchy stress
- \( \mathbf{D}^p \): Rate of plastic deformation

Loss of Hyperbolicity
\[
R_{ij}q_i = 0
\]
where
- \( R_{ij} \): Torsion modulus tensor
- \( q_i \): Unit vector
- \( M \): Tangent modulus tensor
- \( \sigma \): Cauchy stress tensor

Results
Mass Removed after Failure
- Coarse Grid: 25600 cells
- Fine Grid: 102400 cells

Stress Set to Zero after Failure
- Coarse Grid: 25600 cells
- Fine Grid: 102400 cells

No Tensile Stress Allowed after Failure
- Coarse Grid: 25600 cells
- Fine Grid: 102400 cells

Explosive Modeled as a Fluid
- Coarse Grid: 25600 cells
- Fine Grid: 102400 cells

Conclusion: Need transition from failure to fracture. Mesh sensitivity needs to be addressed.