SHOCK17-2017-000109

Abstract for an Invited Paper
for the SHOCK17 Meeting of
the American Physical Society

Examination of ductile spall failure through direct numerical simulation

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Direct numerical simulation is used to examine the growth and coalescence of a random population of voids leading to spall failure. Void nucleating particles are explicitly represented in the initial geometry, and the arbitrary Lagrange-Eulerian finite element code tracks the void evolution to create the spall surface. The flow fields capture strain localization associated with void interaction at low porosities and ligament necking at final coalescence. Simulations are run to assess the influence of material strain hardening and strain rate sensitivity on void growth and coalescence. These analyses also provide the evolution of longitudinal stress and the energy dissipated, and they reveal a length scale associated with the spall. Additional calculations are performed to examine the influence of loading pulse shape on spall behavior for triangular shaped pressure loading. A dependence of spall scab thickness on pulse shape is determined. These results show localization delayed until porosities reach a few percent and they demonstrate a consistent stress versus porosity relation. The simulations also provide a direct correlation between the spall stress history and the free surface velocity, which can aid in understanding stress corrections applied to experimental data.