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Analyzing Isentropic Compression Wave Experiments

DENNIS HAYES, Sandia National Laboratories

Some common assumptions that are used to analyze shock wave experiments are inadequate for analyzing ramp wave compression experiments. Analysis of a Doppler shift through a window usually assumes a steady wave in the window, a condition that is violated when a ramp compression wave steepens as it propagates, requiring separate consideration during the analysis (LiF to 20GPa). Introduction of a free or windowed interface produces large perturbations to the flow in the sample that must be reconciled to achieve required timing accuracy: when the specimen has a unique stress-strain compression relation, the equations of motion are hyperbolic so that stress-strain relation can be directly deduced from measurements on two samples. If the sample is hysteretic like an elastic plastic material, there is not a unique solution to the flow and a separate drive measurement is needed. Time-dependent plasticity (spall in aluminum or twinning in U6Nb) has parabolic equations and backward solutions are unstable. Analyses that compare experiment and simulation have very broad minima in the parameters used to model stress-strain; unconstrained polynomial stress-strain expansions can wander and converge to unreasonable results. Better convergence is achieved with constrained models like certain forms of the Mie-Gruneisen EOS (copper to 18GPa) but those poorly represent materials with large changes in compressibility with strain (HMX to 50GPa). Maintaining small sample thickness to eliminate shock-up while maximizing thickness for accurate wave velocity measurement produces problems for designing high stress experiments and leads to hybrid experimental designs. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.