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Analyzing Isentropic Compression Wave Experiments[1]

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Some common assumptions that are used to analyze shock wave experiments are invalid 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 (sapphire to 20GPa). 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 (W to 250GPa). 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 expansions can wander and converge to unreasonable results. Better convergence is achieved with constrained models like certain forms of the Mie-Grüneisen EOS (Cu to 18GPa) but those poorly represent materials with large changes in compressibility with strain (HMX to 50GPa or β-γ phase change in Sn at 5-8GPa). 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.

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