INVESTIGATING THE DYNAMIC RESPONSE OF SURROGATE ENERGETIC SYSTEMS WITH VARIABLE GEOMETRIC COMPLEXITY

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Abstract

The goal of this research is to understand the dynamic behavior of functional meso-structures fabricated with a mock energetic material, sugar and binder, polydimethylsiloxane (PDMS) in order to control the sensitivity of the system. The approach begins with investigating the dynamic response of PDMS and generating an Equation of State (EOS) model. Experiments were performed in a one-dimensional reverse plate impact configuration at velocities ranging from 29 m/s to 377 m/s. A linear shock velocity, particle velocity fit was applied to the Hugoniot data which resulted in a Hugoniot slope of 2.17 and zero stress shock speed of 1112 m/s. The calibration of the EOS model is accomplished through optimization using the Eulerian hydrocode, CTH coupled with the multi-objective genetic algorithm (MOGA) within an optimization tool, Dakota. A window correction factor of PDMS, 0.0059 was generated by monitoring the particle velocity profile at the impact interface in symmetric plate impact experiments between 0.4 – 1.7 GPa.

The dynamic response of an energetic surrogate mixture of sugar and PDMS, subjected to uniaxial loading, has been investigated. Of particular interest in this investigation were the fluctuations observed at the Hugoniot states of heterogenous mixtures. A unique aspect of these experiments was that the particle velocity along a longitudinal ray could simultaneously be measured due to the transparency of the target to the operating wavelength (1550 nm) of Photonic Doppler Velocimetry (PDV). A distribution of particle velocities was measured; hydrocode simulations were used to better understand their source. Two plausible explanations include, one, the presence of voids around the grain-PDMS interface. Two, the superposition of PDV measurements.

Optimization of mesoscale (~1 mm) geometric structures is performed with a genetic algorithm framework utilizing DAKOTA to enhance a system's dynamic response by energy concentration or dissipation into localized regions. Uniaxial strain experiments were performed with a single-stage gas gun between 80 m/s and 565 m/s projectile velocity to confirm the functionality of the proposed optimized meso-structure. Experimental results indicated that higher and lower velocity responses can be achieved due to the impedance mismatch of building materials directing the shock wave into the predefined directions.