Society of Engineering Science 51st Annual Technical Meeting

1–3 October 2014

Purdue University, West Lafayette, Indiana, USA

Effect of viscoplasticity in HMX grains on ignition probability of dynamically loaded PBXs

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ABSTRACT

A Lagrangian Cohesive Finite Element Method (CFEM) framework is used to study the effect of viscoplasticity in HMX grains on the mechanical response and ignition behavior of two-phase polymer bonded explosives (PBXs) subjected to dynamic loads. The CFEM framework explicitly accounts for dissipation due to viscoelastic deformation of the binder, elasto-viscoplastic deformation of the HMX grains, debonding between the binder and the HMX particles, cracking of the particles and binder, and friction and frictional heating on crack surfaces. Microstructures considered have grain volume fractions from 0.72 to 0.90. Loading at piston velocities ranging from 50 to 200 m/s is considered. To study the ignition behavior, the analyses emphasize statistical quantification with sets of statistically similar microstructures, and explicit account of ignition due to formation of hotspots. To delineate the effects of viscoplasticity and other dissipative mechanisms (debonding, fracture, and friction), calculations are carried out for the same sample sets with and without viscoplasticity. Results show that viscoplasticity in HMX particles significantly affects the ignition sensitivity of PBXs. Specifically, viscoplastic deformation decreases the minimum time required to form critical hotspots and increases the range of potential ignition times. It is also found that viscoplasticity exacerbates the difference in ignition sensitivity between samples with different fractions of HMX. Overall, the evolution of mechanical and thermal fields shows that inelasticity causes heating to concentrate in fewer hotspots with higher temperatures and larger sizes, leading to the behavior shifts observed.