EXPLOSION PERFORMANCE OF ALUMINIZED TNT IN A CHAMBER

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Afterburning can occur when the detonation of an explosive results in fuel-rich products which then react with the surrounding atmosphere. In the case of metallized composite explosives, reactive particles can further increase the fuel richness in the detonation products and react both with oxidizers present in the products and in the shock-heated air. When these explosives are applied to confined environments, reverberating shock waves, vortical flows and turbulence enhance the mixing of the detonation products, metal particles and air, which leads to efficient afterburning energy release. This paper utilizes aluminized composite TNT as a prototype explosive to study chemical, thermodynamic and fluid dynamic effects on the blast and afterburning performance in a closed chamber environment. Theoretical calculations of detonation and constant-volume explosion are performed over a wide range of aluminum mass fractions in TNT using the Cheetah equilibrium code. From these calculations, the equivalence ratio for optimized explosion performance and the lean limit are determined under conditions of ideal mixing of fuel with the air in the chamber. Three-dimensional numerical simulations for the optimized compositions are then conducted to investigate how to achieve the maximized performance of blast and afterburning in dynamic conditions. The numerical models are first examined through a mesh resolution study and validated by the experimental results obtained from the DRDC Suffield 26 m^3 explosion chamber. The chamber is equipped with five pressure transducers and quality experimental data are available for 1.1 kg, 2.2 kg and 4.0 kg cylindrical charges. The numerical models capture details of the charge including shape (cylinder), orientation, booster configurations and ignition location; detonation initiation and propagation; explosive dispersal of aluminum particles; air blast; and afterburning of TNT detonation products and metal particles. The 3D results are compared to 2D axi-symmetric and 1D spherical calculations to display their effect on mixing and afterburning. Results show good agreement with the experiments on transient shock wave interactions, dynamic loading time and quasi-static pressure. From the 3D simulations, the dynamic mixing and afterburning of aluminum particles and TNT detonation products are detected by their concentration distribution and unburned mass in the chamber. Differences between the 3D dynamic calculations and the theoretical equilibrium calculations are discussed.