

Towards LES simulations of the afterburning of High Explosives containing aluminum particles as metallic additive

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Abstract

Explosives are reactive materials whose expected decomposition regime is detonation. They are used due to the high power they generate as the energy stored within the chemical bonds is released within tens of microseconds.

Detonation products are composed of oxidized species such as CO₂ and H₂O, but also CO, C (carbonaceous soots), CH₄ and H₂ if the explosive has a negative oxygen-balance. For explosives detonating in air, a mixing layer is formed at the interface between detonation products and air, where further oxidisation can occur and generate heat. This secondary combustion phase is known as afterburning.

A significant amount of energy is released during this phase, sustaining high pressure levels that result from the detonation. Introducing a metallic fuel within the explosive, such as aluminum, increases the energy released. Aluminum may burn with the oxygen from air, but also with the detonation products. Aluminum energy density is well above that of commonly-used explosives, leading to significant amount of energy released.

Influence of aluminum combustion on the afterburning phase is studied in this work. The combustion solver AVBP is used to model the gaseous phase as well as the aluminum particles using the Lagrangian formalism. The aluminum combustion model uses a correlation determined from experimental measurements of the aluminum combustion time in different configurations of particles diameter and oxidizers composition (O₂, H₂O and CO₂).

Afterburning simulations are initiated by one-dimensional detonation solutions. These solutions are subsequently used to initiate the LES afterburning simulations using AVBP. Adaptive Mesh Refinement (AMR) is also employed to reduce computational cost.

TNT is considered in this parametric study covering a broad range of configurations. The objective is to study the effect of the aluminum mass loading and particle diameter.

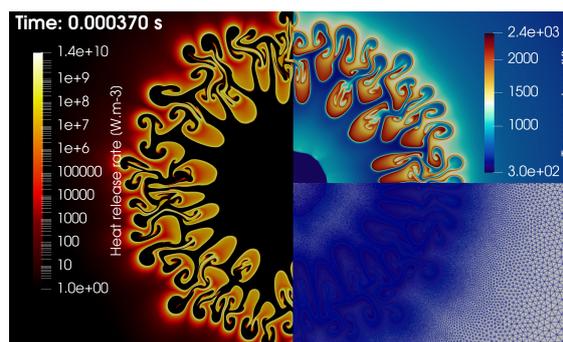


Figure 1: Instantaneous solution from simulation of afterburning phase of 1 gram of TNT.