NUMERICAL INVESTIGATION OF ALUMINUM BURNING BEHIND BLAST WAVES

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Numerical simulation of High Explosive (HE) detonations which contain Al particles is challenging due to the need to model Al particles combustion during and after detonation, in a high-temperature, high-pressure environment which may be oxygen deficient. Hence, scaled experiments are of little use in enhancing our understanding of the controlling physical mechanisms of Al afterburning. Currently, we are developing a new multi-phase flow model which models mass, momentum, and energy exchange as Al particles transition from solid to liquid to gaseous detonation products, and back to the solid, as alumina.

An efficient approach to track billions of particles is to model them in packets, where a packet represents thousands of particles that possess identical position, velocity vectors, and temperature. The governing equations for the multi-phase model are solved in an Eulerian step, while the Al particles are treated in a Lagrangian step, with appropriate transformations between the two. Detailed chemical reaction may require modeling hundreds of reactions, which would result in excessively long computational time. To reduce CPU time to an acceptable level we must carefully select only the most important reactions. Based on past experience, we chose the following six reactions:
(1) C + ½ O2 -> CO, (2)CO + ½ O2 -> CO2, (3)Al + ¾ O2 -> ½ Al2O3 (if $T < T_{decomposition}$), (4)Al + ½ O2 -> AlO (if $T > T_{decomposition}$), (5)Al + 3/2 H2O -> ½ Al2O3 + 3/2 H2, (6)Al + 3/2 CO2 -> ½ Al2O3 + 3/2 C.

The new methodologies are currently being incorporated into our in-house flow solver, FEFLO. The final paper will detail the developed methodologies as well as verification and validation of these models.