THE NATURE OF HETEROGENEOUS BLAST EXPLOSIVES

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Enhanced blast explosives that consist of a mixture of reactive metal particles with a liquid or solid explosive have been investigated over the past decades, in an attempt to utilize the late-time volumetric high chemical-energy release from metal particles mixed with the surrounding oxidizing gases and air. The addition of the particles introduces additional length- (or time-) scales inherent in the mass, momentum, and energy transfer between the particles and the surrounding flow. As a result, the blast wave and flow field generated by the detonation of these heterogeneous explosives differ from that of homogeneous explosives in several important ways. First, the addition of reactive metallic particles to an explosive introduces a new macroscopic length scale which corresponds to the critical charge diameter for which particle ignition occurs (or CDPI). The CDPI depends on particle size and material and more generally on the relative rates of particle heating and expansion cooling of the detonation products. Secondly, for heterogeneous explosives, a considerable fraction of the energy in the detonation products is in the form of kinetic energy of the particles. Hence, depending on the particle size and density, in the near field over a certain distance from the charge, the momentum flux of the particles may exceed that of the gas. In this case, the work done by the flow on nearby structures is primarily due to particle impacts. Thirdly, it is not possible to scale the blast wave parameters with a single energy-scaled length for different particle material, size and shape. Depending on charge diameter, peak pressure and positive impulse can collapse with a degree of scatter intrinsic to the multi-length-scale energy release process of particle combustion. The “skip zone”, which is observed in the energy-scaled blast impulse-distance curves from limited size HE charges, does not always exist for the metallized heterogeneous explosives. Combustion of particles behind a reflected blast and particle fragmentation upon impact add more length-scale effects. Interaction of a reflected shock wave with the combustion products interface and particle flow further enhances the mixing that facilitates the volumetric energy release. The above features of heterogeneous explosives are illustrated using results from an extensive experimental and computational study of heterogeneous explosives with various metal particle materials in a wide range of particle sizes.