DENSE METAL EXPLOSIVES AND ENERGETICS: FUNDAMENTALS AND BEYOND

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Dense metal explosives and energetics refer to an energetic system comprising a large quantity of micrometric or nanometric metals and metal compounds, in an attempt to exploit the high energy and momentum effect of metal particles to enhance blast and the destruction of nearby structures. Their detonation and subsequent dense metal flow and heterogeneous blast constitute an open research area in the dynamics and combustion of dense particle flow. The resulting flow field is characterized by a large number of particle interactions through shocked interstitial fluid and dissipative multibody compaction/collisions, accompanied with additional length (or time) scales for the transfer of mass, momentum, and energy as well as for the dynamic compaction and reaction rates of particles, as a function of particle size and material. This directly limits the validity of both conventional Chapman-Jouguet (CJ) detonation theory and the Sachs-Hopkinson blast scaling law based on a single energy length scale. Furthermore, the entropy consideration of the dense particle flow is overweighed by dynamic effects which manifest themselves through significant particle momentum flux in the near field, particle clustering and jetting, and enhanced mixing of gas-particle flow. Progress in some aspects of phenomenology and applications of this field is depicted in a large number of experiments performed at the Suffield Experimental Proving Ground combined with modeling and theoretical explanation. The review further presents several examples of large-scale heterogeneous blast waves and their particle dynamic and combustion effects from novel dense metal explosives and energetic systems, including hybrid enhanced blast explosives and structural reactive materials. These advances have laid down some fundamentals and technologies for the next stage of developments.