Vol. 13, No. 3, 2004

Compression of Powders in Bridgman Anvil: Fracture and Reaction

A. Gordopolov, O. Dzenis and H.J. Viljoen

Department of Chemical Engineering, University of Nebraska, Lincoln, NE 68588

ABSTRACT

The classical method in initiating thermite reactions is to add thermal energy to the system. An alternative method is to add elastic potential energy until the lattice collapses. Fracture creates large surface areas and non-equilibrium surfaces contain dangling bonds and charged species. Consequently, the fragments are very reactive and little if any additional thermal energy is required to initiate reaction. Lattice failure also marks the transfer of elastic potential energy to kinetic energy of the fragments. The powders that have been studied include reactive mixtures, as well as non-reactive powders. The applied pressure varies between 5 and 8 kbar. Samples, in the form of thin discs, are compressed between two axial platens, but the samples are open at the periphery. During the early stages of compression some material is pushed out in the radial direction. However, a critical thickness is reached where all radial flow of particles stop. The particles in the powder compact locks into a stable structure and it supports the axial load. During this stage some deformation may occur and porosity is reduced to negligible levels. When the axial load reaches a level that exceeds the mechanical stability of the compact, a fracture wave develops. The fracture wave propagates from the periphery toward the center of the disc. Fragments are ejected from the anvil at high velocity; a high-speed camera has been used to measure the ejection velocities. The nonreactive systems are polymethyl methacralate, Bi_2O_3, and $CuSO_4 \cdot 5H_2O$; and the reactive systems include Zn+S and Al+Bi_2O_3. The presence of a metal phase reduces the ability of the system to store elastic potential energy and ejection velocities are lower. Another interesting result is that the lattice may collapse in stages, with pauses between consecutive collapse events. In the case of Zn+S system, as many as seven distinct collapsing events have been observed in a single experiment.

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