INFLUENCE OF DISTRIBUTED SOLID-PHASE REACTIONS ON DEFLAGRATIONS IN CONFINED POROUS PROPELLANTS

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Abstract

Combustion processes in energetic materials are often modeled by a surface gasification reaction followed by a distributed gaseous flame. However, under confinement, a deflagration is generally accompanied by an increasing pressure difference, or overpressure, between the burned-gas region and the unburned reactants deep within the pores of the energetic material. As the overpressure and/or the solid-phase reaction rate become sufficiently large, the gaseous and solid reaction zones tend to merge into a single multiphase reaction region. Furthermore, in certain parameter regimes, the flame penetrates into the porous solid, resulting in subsurface gaseous combustion. When the activation energies of the gaseous and solid-phase reactions are of the same order of magnitude and/or the overpressure becomes significant, gasification reactions may actually become active within the solid, thus eliminating a distinct propellant surface and forming a distributed multiphase reaction layer. A large activation-energy analysis of this scenario is presented in order to study the effects of distributed solid reactions on the deflagration structure and the burning-rate response. The burning-rate eigenvalue is obtained from a numerical solution of the reaction-zone problem, and the results are calculated for various overpressures as well as different gas-to-solid activation-energy and thermal conductivity ratios. It is observed that increasing overpressure results in a more spatially distributed solid-phase reaction and a rapidly increasing flame-propagation speed.