MODELING COMBUSTION OF ALUMINUM PARTICLES IN SHOCK-DISPERSED-FUEL EXPLOSIONS

A. L. Kuhl[1], B. Khasainov[2], J. B. Bell[3]

[1] *University of California Lawrence Livermore National Laboratory, Livermore, CA USA*
[2] *Laboratoire de Combustion et Détonique, UPR 9028 CNRS, 86961 Futuroscope, France*
[3] *University of California Lawrence Berkeley National Laboratory, Berkeley, CA USA*

We present a two-phase Model for simulating experiments of combustion in Shock-Dispersed-Fuel (SDF) explosions. Experimental results were reported at the 18th MABS (Kuhl, Neuwald & Reichenbach; 2004). The SDF charge consisted of a 0.5-g spherical PETN booster, surrounded by 1-g of fuel powder (e.g., flake aluminum, carbon powder, polyethylene granules, or TNT powder). Detonation of the booster charge creates a high-temperature, high-pressure source (PETN detonation products gases) that both disperses the fuel and heats it. Combustion ensues when the fuel mixes with air. The gas phase is governed by the gas-dynamic conservation laws (Giovangigli, 1999). The particle phase obeys the continuum mechanics laws for heterogeneous media (Nigmatulin, 1987). The two phases exchange mass, momentum and energy according to inter-phase interaction terms (Khasainov & Veyssiere, 1996). The kinetics model used an empirical particle burn relation (Ingignoli, 1999). The thermodynamic model considers the air, fuel and booster products to be of frozen composition, while the Al combustion products are assumed to be in equilibrium. The thermodynamic states were calculated by the Cheetah code; resulting state points were fit with analytic functions suitable for numerical simulations. Numerical simulations of combustion of an Aluminum SDF charge in a 6.6-liter chamber (H=21 cm, D=20cm) were performed. Computed pressure histories agree with measurements (Fig. 1). Simulations were also performed for an un-confined Al-SDF explosion; it is interesting to note that fuel consumption histories were similar for the confined and un-confined cases. A detailed description of the Model and the evolution of the flow field will be presented at MABS-19.

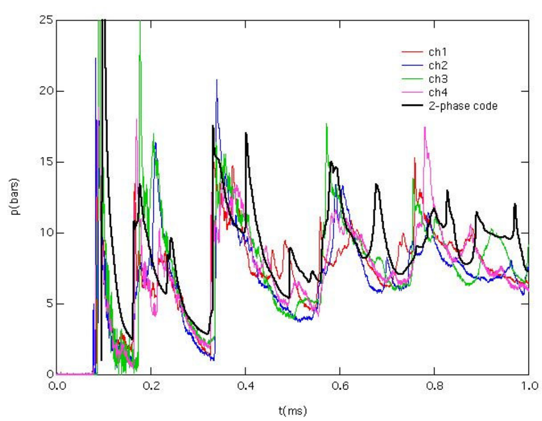

Figure 1. Comparison of calculated pressure history with data (channels 1-4) for an explosion of an Al-SDF charge in a 6.6-liter cylindrical chamber (gage location: z = 10.5 cm, r = 5 cm).