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Impact of the matrix/filler interfacial properties on the local damage and macroscopic behavior of propellants

Julie Diani[1], F. de Francqueville[1,2] and P. Gilormini[3] and A. vandenbroucke[2]

[1] Laboratoire de Mécanique des Solides, CNRS UMR 7649, École Polytechnique,
Institut Polytechnique de Paris, Route de Saclay, 91128 Palaiseau, France,
julie.diani@polytechnique.edu

[2] ArianeGroup, Centre de recherche du Bouchet, 9 rue Lavoisier, 91710 Vert-le-Petit,
France

[3] Laboratoire PIMM, ENSAM, CNRS, CNAM, 151 bd de l'Hôpital, 75013 Paris, France

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Solid propellants are made of a very high volume fraction of energetic particles within a polymeric binder. Their main purpose is to deliver a phenomenal thrust while burning in order to launch rockets. However, to control the kinetics of combustion and avoid a catastrophic accident, specific stress and strain at failure are targeted. Therefore, the development of new propellants with enhanced combustion properties requires to provide materials with similar or better mechanical properties in terms of both strength and toughness. In order to do so, it is necessary to understand the impact of the microstructure and of the mechanical properties of the constitutive phases, on the composite behavior. The present contribution aims at using a micromechanical modeling approach to describe the link between the local mechanical behaviors and damage, and the macroscopic mechanical behavior of solid propellants.

The micromechanical approach consists in finite elements analyses on periodic microstructures of particles embedded in a soft non-linear matrix (Figure 1). Two types of particles have been considered, either spheres or non-regular polyhedra in order to study the impact of edges and sharp vertices. In such industrial materials, the damage appears as binder debonding around the larger particles. Damage at the matrix/filler interface is taken into account with a cohesive-zone model (CZM) and the impact of the CZM parameters on the propellant-like material local damage and macroscopic behavior is discussed.

The micromechanical model will be confronted to the different macroscopic responses of three model propellants that have been tested in uniaxial tension while monitoring their volume changes for quantifying the macroscopic damage, and looking at the local damage with scanning electron microscopy images.

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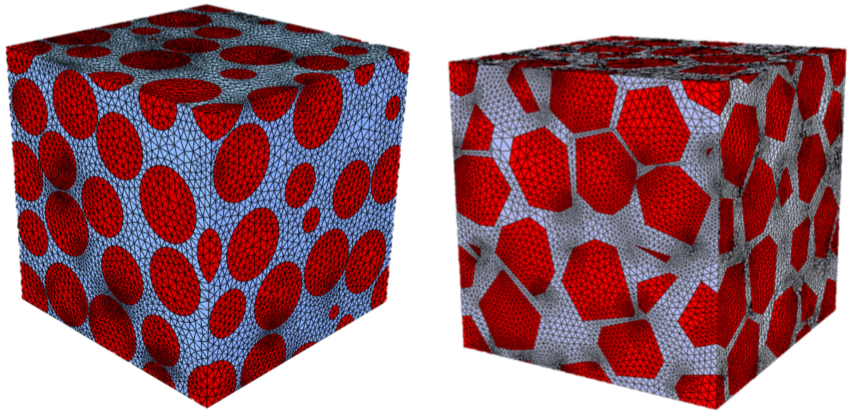

Figure 1: Periodic microstructures of a rubbery matrix filled with monodispersed sphere or non-regular polyhedra

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