



PhD thesis in mechanics

Title : Sensitivity of energetic formulations : effect of damage and microstructure

Context : Shock sensitivity is often studied in order to improve on the security of energetic materials (i.e., explosives). Numerous studies have shown that the former is sensitive to microstructural characteristics. However, the exact mechanisms responsible for the interplay between mechanical damage, microstructure heterogeneities (grains shape, intra or extra-granular effects) during initiation have not been elucidated.

The PhD thesis is proposed by the ISL (French-German research institute), the CEA Gramat (French Atomic Energy Commission) and École des Mines (Paris). ISL and CEA have started a collaboration on this topic in 2015. Formulations of "RDX" and wax have been produced and experimentally characterized at ISL whereas CEA has conducted microtomography analysis. Experimental studies carried out at ISL have shown that shock sensitivity is reduced when the density of intra-granular defects decreases, and that morphology also plays a role. This underlines the effect of the mechanical behavior in these explosives. The Centre for Mathematical Morphology (CMM) of Mines ParisTech develops numerical models of random structures representative of complex microstructures and homogenization tools that are used to predict the mechanical response of heterogeneous media. The laboratory also specializes in image analysis.

Goal of the thesis :

During the thesis, the PhD student will carry out a combined experimental and numerical study of the material in order to understand the evolution of damage in microstructures, identify the relevant morphological parameters when the material is subject to a given solicitation. Emphasis will be put on the numerical aspects. This point is of particular importance to security and to the understanding of the transition between shock and detonation.

On the one hand, material tests will be carried out on energetic samples with varying microstructures, to study the connection between dynamical loadings and local damage. On the other hand, numerical tools will be developed at the mesoscopic scale to study damage, using virtual and image-segmented microstructures.

Thesis work :

The PhD student will be located at the Centre for Mathematical Morphology first (École des Mines de Paris, located in Fontainebleau), and at the Centre of study of CEA Gramat (Lot, France) in a second time. Most experimental work will be carried out at the ISL French-German institute. The main steps of the work include :

- A bibliographical work on experimental studies of damage mechanisms in similar composites and a critical analysis of numerical methods in literature.
- Realization and characterization of samples and local constituents.
- Analysis by microtomography and image analysis.
- Impact tests and study of damaged samples.
- Development of tools used to simulate damage at the mesoscopic scale, validation of the methods with experiments.
- Phenomenological study of the effect of morphology and defects. using virtual microstructures.



Thesis director : Petr Dokladal. The student will be awarded a doctoral degree from the école doctorale 432 "Sciences des Métiers de l'Ingénieur". Work will be supervised by the thesis director and B. Erzar (CEA), F. Willot (Mines), J. Corbel (ISL), L. Borne (ISL).

How to apply :

An excellent scientific background is required and solid knowledge in mechanics and/or applied mathematics. The candidate must hold a master 2 degree or an equivalent degree. A first experience in research (master internship) or publications, will be greatly appreciated. An excellent level of English and high motivation of doing research is a pre-requisite.

Please send your CV, master (or other degrees) marks as well as any other relevant document (persons who can be contacted for recommendation, internship or project reports).

Contact :

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