Dynamic damage and fracture of a HMX-based PBX

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The French Commission for Atomic and Alternative Energies is interested in the prediction of the ignition of energetic materials that experience low velocity impacts. The ignition mechanism for such loadings is described as non-shock ignition and is localized at the structure micro scale. Among the attempts to explain such ignition, the micro cracks friction is suspected. At the structure scale, continuum damage mechanics in dynamics is well appropriated to model the problem. However, one of the major difficulties in the numerical simulation of damage is due to the localization phenomenon. Industrial computational codes based on finite element method fail to simulate such localization because there is no related length scale in the formulation. Indeed, a local constitutive law is assumed and pathological mesh dependence is obtained. In the work made with co-workers Kévin Moreau, Nicolas Moes and Laurent Stainier [1], a recent non local formulation based on a thick level set is studied. This approach, already used for quasi-static loadings conditions, has been extended to dynamic problems. Dynamic introduces the notion of time in the equations and the damage front velocity is upper bounded by the model. Non local related computational costs are limited to a slightly region around the damage front and remain acceptable in an explicit context.

In the experimental part of the study, a reversed edge-on impact test has been developed to obtain an initial view of the microstructure (large crystals embedded in a “dirty binder”) and real-time and post-mortem observations of the deformation of the microstructure when submitted to static or dynamic loadings [2]. Images highlight the behavior of the matrix/grain interface. Decohesion is observed without tangential friction and hot spot formation is thus excluded in these interfaces. Depending on the loading conditions (for example of the confinement), the stiffness of the matrix evolves and plasticity and microcracking can be observed into the larger crystals. The location and the possible hot spot formation mechanisms will be discussed.

References

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[2] J. Vial, D. Picart, P. Bailly, F. Delvare, Numerical and experimental study of the plasticity of HMX during a reverse edge_on impact test, Modelling, Simul. Mater. Sci. Eng. 21, 045006, 2013.