Statistical analysis of ductile damage under impact loading

Corentin Thouénon*[1,2], Alizée Dubois[1], Jacques Besson[3], and François Willot[4]

[1]Laboratoire Matière sous Conditions Extrêmes – CEA DIF – France
[2]Centre des Matériaux – MINES ParisTech - École nationale supérieure des mines de Paris – France
[3]Mines Paris, PSL Research University, Centre des Materiaux, CNRS UMR 7633, 63–65 rue Henri-Auguste ´ Desbrueres, Corbeil-Essonnes, 91003, – Mines Paris, PSL Research University, Centre des Materiaux – France
[4]Centre de Morphologie Mathématique (CMM) – MINES ParisTech - École nationale supérieure des mines de Paris – 35 rue Saint-Honoré 77305 Fontainebleau cedex, France

Abstract

Spalling is a fundamental damage phenomenon observed in materials under dynamic loading. Experimental adjustments in strain rates and shock pressures, achieved through variations in shock generation methods (such as mechanical impact or laser shock), allow for modifications in fracture properties. In ductile materials, the microscopic mechanism behind spall cracks involves the nucleation, growth, and coalescence of pores in the plane intersected by relaxation waves. Many damage models assume independent collections of pores, overlooking potential collective effects among them. The proposed statistical approach aims to uncover correlations in the spatial distribution of pore sizes and investigate variations in pore areal density with strain rate. Employing scanning electron microscopy and stereo-imaging, this method enables statistical analysis of 3D reconstructions of post-mortem spall surfaces. The objective is to advance both damage models and our comprehension of the fundamental underlying mechanisms.

*Speaker