20th European Mechanics of Materials Conference - EMMC20
Florence, Italy | May 27th-29th, 2026
www.emmc20.unifi.it

Bayesian calibration of a simplified model for ductile spalling accounting for viscoinertial and nucleation effects

Clément Cadet[1], Yann Coget[2], Alizée Dubois[3]

[1] CEA DAM DIF ; Université Paris-Saclay, CEA, Laboratoire Matière en Conditions Extrêmes, France.
clement.cadet@cea.fr
[2] CEA DAM DIF, France. yann.coget@cea.fr
[3] CEA DAM DIF ; Université Paris-Saclay, CEA, Laboratoire Matière en Conditions Extrêmes, France.
alizee.dubois@cea.fr

Paper ID: 167
Symposium S8: Fracture, and damage of materials

Abstract

Materials undergoing high strain rate loading, for instance during plate impact experiments, may experience spalling. For ductile materials such as tantalum, this failure mode takes place by nucleation of voids, growth and coalescence. Void growth is sensitive to strain rate effects due to viscoplasticity [1] and the inertia of the void-surrounding matrix [2]. As this microinertia involves a characteristic length scale, coupling it with nucleation models is challenging. Some models do exist but they may be computationally expensive [3] and are not equivalent [4] to common nucleation models [5] at low strain rates. To solve these issues, a simplified model for ductile spalling combining viscoinertial effects and nucleation is developed. Throughout loading, voids are nucleated with a small nonzero initial radius according to a Weibull distribution of stress thresholds. At each time step, for already existing voids and newly nucleated ones, a volume average is performed for the radius and radius increase rate. The homogenization hypotheses are verified by comparing this new model to the response of an assembly of pores, following the methodology of [3]. A Bayesian calibration [6] is then performed on plate impact experiments: for the new model and simpler ones (without nucleation or microinertia), simulations are carried out with a hydrocode, then characteristic points of the free surface velocity curve are extracted. After having built metamodels of these outputs, a Markov Chain Monte-Carlo approach allows computing posterior distributions of the parameters. Finally, the calibration results are used to compare the ability of the different models to match the experimental data.

Keywords:

ductile failure high-strain-rate loading spalling Bayesian calibration

References:

[1] Johnson, J. N. (1981). Dynamic fracture and spallationin ductile solids. Journal of Applied Physics, 52(4),2812-2825.

[2] Molinari, A., & Mercier, S. (2001). Micromechanicalmodelling of porous materials under dynamic loading.Journal of the Mechanics and Physics of Solids, 49(7),1497-1516.

[3] Czarnota, C., Jacques, N., Mercier, S. M. L. U., &Molinari, A. (2008). Modelling of dynamic ductile fractureand application to the simulation of plate impact tests ontantalum. Journal of the Mechanics and Physics of Solids,56(4), 1624-1650.

[4] Jacques, N., Mercier, S., & Molinari, A. (2015). Aconstitutive model for porous solids taking into accountmicroscale inertia and progressive void nucleation.Mechanics of materials, 80, 311-323.

[5] Needleman, A., & Tvergaard, V. (1984). An analysis ofductile rupture in notched bars. Journal of the Mechanicsand Physics of Solids, 32(6), 461-490.

[6] Perrin, G., & Pillon, L. (2018). Calibration ofJohnson's damage model by a Bayesian approach. In EPJ Webof Conferences (Vol. 183, p. 01037). EDP Sciences.