Plastic localisation and ductile fracture of electromagnetically-loaded sheet metal plates

Borja Erice[*,1], **Dirk Mohr**[1,2]

[1]Solid Mechanics Laboratory (CNRS-UMR 7649), Department of Mechanics,
École Polytechnique, Palaiseau, France.
e-mail: borja@lms.polytechnique.fr

[2]Impact and Crashworthiness Lab, Department of Mechanical Engineering,
Massachusetts Institute of Technology, Cambridge MA, USA

ABSTRACT

Electromagnetic forming (EMF) processes are typically completed in less than one millisecond which implies that the material deforms at strain rates of the order of 10^3/s. The remarkable feature of EMF is an apparent increase of the formability limits as compared to conventional mechanical forming processes. To shed some light on the underlying mechanisms, the plastic localisation and the neck formation of the mechanical and electromagnetic forming processes are analyzed computationally. The finite element model of the EMF processes assumes linear electromagnetic constitutive equations and time-independent electric induction to estimate the Joule heating and the Lorentz forces. To evaluate the thermo-mechanical response of the material, a Hill yield surface with non-associated flow rule and an isotropic mixed Swift-Voce strain hardening model with additional Johnson-Cook strain-rate and temperature dependence were considered. The dynamic ductile fracture behaviour was assessed with the uncoupled rate-dependent Hosford-Coulomb failure criterion. It is found from a case study on the forming of hemispherical cups that the apparent increased formability is a direct outcome of the enhanced uniformity in the mechanical fields when applying the loading through Lorentz forces.