Development of an experimental set-up for the study of the dynamic damage of metals

Martin Sicard*[1,2], Patrice Longère[1], Gabriel Seisson[2], and Mathieu Xavier[3]

[1]Institut Supérieur de l'Aéronautique et de l'Espace – Institut Clément-Ader (ICA); Université de Toulouse ; CNRS, UPS, IMT Mines Albi, INSA, ISAE–SUPAERO; 3 rue Caroline Aigle, F-31400 Toulouse CEDEX 04, France – France
[2]GRAMAT – CEA DAM Gramat – France
[3]CEA/DAM [Arpajon] – CEA, DAM, DIF, Arpajon, France – France

Abstract

Keywords: Ductile damage – High strain rate – Nonlinear constitutive modelling
Highly space- and time-resolved experimental data are needed for better understanding and further modelling the mechanisms that govern the damage and fracture of metallic materials and structures in a wide range of strain rates and stress triaxiality ratios.

For that purpose, a plate-impact-driven ring expansion test (PIDRET) set-up using a single-stage gas gun, PDV probes and ultra-high-speed cameras, see (1), is adapted to apply a tension-by-expansion loading to notched rings with achievable local strain rates of the order of 10ˆ6 sˆ{-1}. Completed by (i) quasi-static tension tests carried out using a standard hydraulic machine and (ii) moderately dynamic tension tests using a split Hopkinson tension bar apparatus, the aim is to cover the strain rate range (10ˆ{-3} sˆ{-1} , 10ˆ6 sˆ{-1}) and the stress triaxiality range (0.3 , 1). Results obtained are intended to feed a coupled plasticity-ductile dynamic damage model, such as the GTN one, see (2).

Notch dimensions were designed by finite element analyses using the commercial computation code Abaqus-Exp. The feasibility of the dynamic tension-by-expansion test and the repeatability of the experimental results are investigated considering various metals and alloys.

References

(1) Gant, F., et al. High strain rate responses of some metals and alloys using a plate impact driven ring expansion test (PIDRET). Int. J. Impact Eng., vol. 184, p.104829 (2024)
(2) Tvergaard V., Needleman A., Analysis of the cup-cone fracture in a round tensile bar, Acta metall, 32(32):p.157-169 (1984).

*Speaker