MULTIPLE NECKING IN DYNAMIC EXPANSIONS OF PLATES, CYLINDERS AND SPHERES:
THEORY AND EXPERIMENTS

S. Mercier(1) and A. Molinari(1)

In collaboration with N. Granier, F. Llorca(2) and T. Grunenwald(2)

(1) LPMM/ University Paul Verlaine- Metz, Ile du Saulcy, 57045 Metz, France
(2) CEA/VALDUC, 21120 Is sur Tille, France

In rapid stretching, structures develop a multiple necking pattern which leads to the fracture in several fragments as observed on different experimental configurations by Niordson (1965), Zhang and Ravi-Chandar (2006) for example.

In the first part of the talk, we propose to concentrate on the onset of the multiple necking via a linear stability analysis. In Fressengeas and Molinari (1994), it was shown that the interplay between multidimensional effects and inertia could lead to the selection of a necking pattern. The former approach has been revisited recently by Mercier and Molinari (2003), adopting the formalism of Shenoy and Freund (1999). Using this new approach, the multiple necking of rods, plates and cylinders was analyzed. From the work dedicated to cylinders, it was observed that the effect of curvature is negligible when the structure is thin (thickness/mean radius below 0.1).

.
In the second part, multiple necking for hemispherical shells is analysed. Rapid expansions of hemispheres at strain rates of the order of few 1000 s-1 have been performed by the CEA. The deformation of the hemisphere was recorded by rapid camera. The onset of necking was determined with a good accuracy. From numerical simulations, it is observed that the multiple necking is triggered on location where plane strain deformation develops. In addition, since the hemisphere is thin, the proposed theory developed for plates can be used to model these experiments. A comparison between theoretical results and rapid expansions of hemisphere demonstrates the pertinence of our approach with regards to the number of necks and also to the prediction of strain at the onset of instabilities.

References:
Niordson FI (1965), Exp. Mech. 5:23-32
Zhang and Ravi-Chandar (2006), Int J. Fract. 142:183-217
Fressengeas and Molinari (1994), Eur J. Mech-A-Solid 13:251-268
Mercier and Molinari (2003), Int. J. Solids Struct 40:1995-2016
Shenoy and Freund (1999) J. Mech. Phys. Solids 47:2209-2233
Mercier, Granier, Molinari, Llorca, Buy (2010), J. Mech. Phys. Solids.

e-mail: S. Mercier: mercier@lpmm.univ-metz.fr