A comparative study of the dynamic fragmentation of non-linear elastic and elasto-plastic rings: the roles of stored elastic energy and plastic dissipation.

A.Vaz-Romero*, S. Mercier†, J.A. Rodríguez-Martínez*† and A. Molinari†

* Department of Continuum Mechanics and Structural Analysis. University Carlos III of Madrid. Avda. De la Universidad, 30. 28911 Leganés, Madrid, Spain.

† Université de Lorraine, CNRS, Arts et Métiers ParisTech, LEM3, F-57000 Metz, France

ABSTRACT

We develop a comparative analysis of the processes of dynamic necking and fragmentation in elasto-plastic and hyperelastic ductile rings subjected to rapid radial expansion. For that purpose, finite element simulations have been carried out using the commercial code ABAQUS/Explicit. Expanding velocities which range between 25 m/s and 600 m/s have been investigated. The elasto-plastic material and the hyperelastic material are modelled with constitutive equations which provide nearly the same stress-strain response during monotonic uniaxial tensile loading, and fracture is assumed to occur at the same level of deformation energy. The computations have revealed that, while the number of necks nucleated in the elasto-plastic and hyperelastic rings is similar, the mechanisms which control their development are significantly different. In the elasto-plastic rings several necks are arrested due to the stress waves which travel the specimen after the localization process has started, and thus the number of fractures in the ring is significantly lower than the number of incepted necks. On the contrary, these stress waves do not stop the development of any neck in the hyperelastic rings. The elastic energy released from the sections of the ring which are unloading during the localization process fuels the development of the necks. Hence, for the whole range of investigated velocities, the proportion of necks that develop into fracture sites is much greater for the hyperelastic rings than for the elasto-plastic ones. The comparison between the numerical results obtained for both materials brings to light the roles of elastic unloading and plastic dissipation in multiple necking and fragmentation processes.

REFERENCES

[1] Ravi-Chandar, K., Triantafyllidis, N., 2015. *Dynamic stability of a bar under high loading rate: Response to local perturbations*. International Journal of Solids and Structures 58, 301-308.

[2] Vaz-Romero, A., Rodríguez-Martínez, J. A., Mercier, S., Molinari, A., *Multiple necking pattern in nonlinear elastic bars subjected to dynamic stretching: The role of defects and inertia.* International Journal of Solids and Structures, 2017, 125, 232-243.