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A spectral method to study the onset of necking instability for dynamic plane strain

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During dynamic expansion of thin ductile metal cylinders, the deformation is first homogeneous. Then necking instabilities appear which generate local thinning, triggering plastic localization and finally the fragmentation of the structure. The present work aim is to provide new developments for the predictions of the fragment size and velocity.

In order to study the onset of necking instability, linear stability analyses (LSA) are adopted to determine a critical wavelength which develops with the fastest growth rate. It has been shown that LSA can provide deep understandings of experimental results like the number of necks or their time of occurrence after some calibrations [1] [2].

However, the previous approaches suffer from some drawbacks. Indeed, based on a frozen coefficient theory, the model is salient when the time scale inherited from the development of the necking is smaller than the time scale of the background solution. Such conditions are no more satisfied for stretching rate over $10^4 s^{-1}$.

In the present talk, a new contribution is proposed. The time and space evolution of any perturbations is captured via a system of linearized equations. A Tau spectral method is adopted. Dynamic plane strain loading is investigated on a thin plate configuration, representative of a thin cylinder expansion. The material is incompressible. Its behavior is rigid viscoplastic, satisfying a J2 flow theory .

As a result, different initial defects have been considered. Their time and space evolution have been captured by the new method. It has been seen that while the perturbation evolution is highly depending on the shape of the defect in the early stage of the deformation process, their long term evolution is quite close to the one predicted by the classical LSA. We have checked that at least for strain rate lower than $10^3 s^{-1}$, the instantaneous growth rates predicted by the classical LSA and the new contribution are consistent. In a next step, larger strain rate loading will be investigated.

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