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Discussion

Response to the comments by Hucthinson and Tvergaard

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We agree with the criticism raised by Professors Hutchinson and Tvergaard in their comment of our recent article (Danas and Ponte Castañeda, 2012). Indeed, our model, which is based on the use of an approximate homogenization technique, can only generate estimates for the evolution of the "average" shape of the pores, as determined by the aspect ratio of a "representative" ellipsoidal void evolving with the average strain-rate in the vacuous phase (as predicted by the homogenization technique). On the other hand, the FEM unit-cell calculations presented by Hutchinson and Tvergaard suggest that the void can assume strongly non-ellipsoidal shapes at the very large deformations near complete void collapse. As a consequence, the contact between the surfaces on opposite sides of the voids can considerably slow down, or even stop altogether, collapse of the voids. At low values of the triaxiality ($0.1 \leqslant T \leqslant 0.5$) and for axisymmetric loadings with Lode parameter $L = +1$, the predictions of the homogenization model for strain localization occur for unrealistically large values of the void aspect ratios, where interference of the void faces is expected to have already taken place. Therefore, the predictions of the model for localization strains at $L = +1$ and for such low values of T are inconsistent with the FEM unit-cell calculations of Hutchinson and Tvergaard, and must be called into question.

Further work, both experimental and numerical, is needed to clarify the effect of void shape changes on the macroscopic response of metals with evolving porosity, as well as their possible implications for failure through localization of deformation, especially in the low-triaxiality regime. Our recent paper (Danas and Ponte Castañeda, 2012), as well as earlier work (e.g., Ponte Castañeda and Zaidman, 1994) strongly suggests that the evolution of the average shape of the voids under low triaxiality loading conditions is a potentially important effect that must be properly accounted for. However, as the results presented by Hutchinson and Tvergaard clearly demonstrate, other effects, such as contact and slip of the void faces (Tvergaard, 2009; Dahl et al., 2012), are also very important and can play a determining role at least in certain loading regimes.

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