Multiscale Modelling of Ductile Porous Metals: Determination of Macroscopic Yield Surfaces

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Abstract

In this paper, yield surfaces for porous ductile metals under plane strain are estimated by means of a computational multiscale approach based on the volume averaging of the microscopic stress and strain tensors over a Representative Volume Element (RVE). At the RVE level, standard von Mises plasticity model is employed to describe the matrix behaviour. The effects of void ratio and void distribution, as well as of different kinematical constraints over the RVE, on the macroscopic response are assessed. In this context, RVEs of square geometry with a centred void are employed. The computational implementation of the present methodology within a non-linear finite element framework is non-conventional. The main difference between conventional finite elements and the present implementation lies in the generation of the finite-dimensional spaces of virtual displacements of the RVE according to the (possibly non-standard) adopted kinematical constraint. This issue is addressed here with the direct enforcement of the kinematical constraints within the non-linear equilibrium solution procedure. The methodology used to estimate the yield surface of the porous metal is similar to that proposed by Gurson in his landmark paper. Sets of yield surface points in the p-q space are obtained by computing numerically the macroscopic stress corresponding to the plastic collapse of the RVE. The macroscopic yield function is then approximated by curve fitting of the computed points. In this context, new yield functions for porous ductile metals are proposed which accurately fit the numerical data generated by the present multiscale approach. The results are compared with the yield function proposed by Gurson. We remark that, differently from Gurson's approach, no specific collapse mechanisms are explicitly assumed and the actual mechanisms here depend upon the chosen RVE kinematical constraints.

Key words: Multi-scale modelling, porous plasticity, Gurson model, finite element.

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