A parametric analysis of void coalescence mechanisms based on 3D finite element microscale computations

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ABSTRACT

Ductile fracture of metallic materials is known to be based on the mechanisms of voids nucleation, growth and coalescence. Coalescence is characterized by the initiation of micro-cracks between voids leading to final fracture. The most observed coalescence mode is due to internal necking between neighbouring voids with plastic localization in the intervoid ligaments. For lower stress triaxiality ratios, a shear driven localization mode can also be observed [1]. This mode, often called void-sheet coalescence, is not yet perfectly understood. It is observed usually in 2D micrographs or 2D X-ray tomography pictures without accounting for the influence of other voids possibly located deeper in the material.

The present study aims at studying the interaction between voids in a 3D finite element (FE) framework to study possible 3D effects. Simulations are performed using full field FE simulations of ductile fracture at the microscale. Meshing and remeshing methods relying on the use of Level-Set functions are proposed to discretize the microstructure and its behavior under large plastic strain [2, 3]. These numerical methods are extended to account for cracks and model the microstructure failure mechanisms and in particular the coalescence stage. This new FE approach is used here to study the influence of voids position on coalescence mechanisms.

Comparisons with experimental data provided by X-ray laminography experiments coupled with digital volume correlation (DVC) are also provided for a nodular cast iron material [4].

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