Modeling Void-by-void Growth vs. Void Interaction in Thin Sheet Metal

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A range of metallic materials compose of a mix of two phases, i.e. a metal matrix that enclose small hard/tough inclusions. When subject to loading, the inclusions can fracture or decohese, effectively creating voids which subsequently grow and coalescence to form micro-cracks. This mechanism governs failure in many ductile metals and it is known that ductile crack propagations can take place by one of two events; i) Void-by-void growth where individual voids grow large before neighboring voids are effected and experience significant growth, ii) multiple voids interaction where a number of neighboring voids grow simultaneously. The governing mechanism depends on initial void size and position relative to the crack front, and a first 2D plane strain study can be found in Tvergaard and Hutchinson (2002) [Int. J. Solids and Struct., 39:3581-3597]. The present work takes this early study to full 3D and considers an array of voids in front of a crack within a thin metal sheet. Here, considering different configurations of the voided array to gain a parametric understanding of the influence on the void interaction and failure mechanisms as-well as its effect on the tunneling effect of an initiating crack tip. Throughout, Mode I loading is applied and the analysis is carried out by the finite element method using an in-house massively parallel code to resolve the small scales details around the individual voids. The study allows for the 3D interactions of micro-voids to be brought out and hence predict the void growth in the transverse direction to the sheet. E.g. the tunneling of an initiating crack is studied in details and held against experimental observations.