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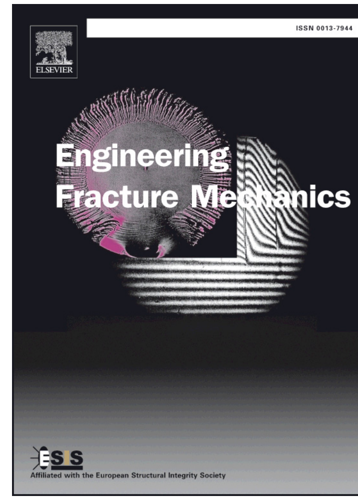

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C. Tekoğlu

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Void Coalescence in Ductile Solids Containing Two Populations of Voids

C. Tekoğlu*

Department of Mechanical Engineering, TOBB University of Economics and Technology, Söğütözü, Ankara, 06560, Turkey

Abstract

Many metallic alloys contain a primary and a secondary population of voids, the difference in size reaching up to orders of magnitude. The present study extends Thomason's and Lenlond-Benzerga's criteria for the onset of coalescence of primary voids to incorporate the effects of a secondary population. Plastic limit load analysis is performed within a finite element (FE) framework by using three dimensional (3D) cubic unit cells. The macroscopic stress state of the unit cells corresponds to axisymmetric tension with $\Sigma_{22} > \Sigma_{11} = \Sigma_{33}$. The extended versions of both criteria are able to successfully predict the critical stress for the onset of coalescence.

Keywords: Finite element analysis, Limit load, Micromechanics and/or materials mechanics, Ductile fracture, Void coalescence

1. Introduction

In ductile fracture, voids, which nucleate either by brittle fracture or decohesion of inclusions, grow and get closer through the plastic deformation of the surrounding base material. At the *onset of void coalescence*, the more or less uniform plastic deformation of the base material during void growth suddenly localizes in the ligaments connecting adjacent voids, while the regions outside the ligaments unload elastically. During the coalescence phase, rapidly growing neighboring voids merge with one and other, initiating and propagating macroscopic cracks leading to fracture of the material. There are three different experimentally observed modes of void coalescence: (i) *internal necking*, (ii) shear coalescence (see e.g. Bandstra and Koss [2], Cox and Low [10], Nielsen and Tvergaard [25], Tvergaard [45, 46], Tvergaard and Nielsen [47]), and necklace coalescence (see e.g. Benzerga [4], Gologanu et al. [17]). In internal necking, the ligament between merging voids shrinks in a similar way to the necking phenomenon observed in macroscopic specimens under uniaxial tension. In the following, we will focus only on internal necking.

*Corresponding author. Tel.:+90 312 292 42 29 ; fax:+90 312 292 40 91.
Email address: cihantekoglu@etu.edu.tr; C.Tekoglu@gmail.com (C. Tekoğlu)