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Ying-Song Ma , Dong-Zhi Sun , Florence Andrieux , Ke-Shi Zhang

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Influences of initial porosity, stress triaxiality and Lode parameter on plastic deformation and ductile fracture[1]

Ying-Song Ma [a,b,c], Dong-Zhi Sun [c*], Florence Andrieux [c], Ke-Shi Zhang [a*]

[a] College of Civil Engineering and Architecture, Guangxi University; Key Lab of Disaster Prevention and Structural Safety; Guangxi Key Lab Disaster Prevention and Engineering Safety; Nanning 530004, China
[b] Department of Mining Engineering, Shanxi Datong University, Datong 037003, China
[c] Fraunhofer Institute for Mechanics of Materials IWM, Woehlerstrasse 11, 79108 Freiburg, Germany

Abstract

Local mechanical properties in aluminum cast components are inhomogeneous as a consequence of spatial distribution of microstructure, e.g., porosity, inclusions, grain size and arm spacing of secondary dendrites. In this work, the effect of porosity is investigated. Cast components contain voids with different sizes, forms, orientations and distributions. This is approximated by a porosity distribution in the following. The aim of this paper is to investigate the influence of initial porosity, stress triaxiality and Lode parameter on plastic deformation and ductile fracture. A micromechanical model with a spherical void located at the center of the matrix material, called the representative volume element (RVE), is developed. Fully periodic boundary conditions are applied to the RVE and the values of stress triaxiality and Lode parameter are kept constant during the entire course of loading. For this purpose, a multi-point constraint (MPC) user subroutine is developed to prescribe the loading. The results of the RVE model are used to establish the constitutive equations and to further investigate the influences of initial porosity, stress triaxiality and Lode parameter on elastic constant, plastic deformation and ductile fracture of an aluminum die casting alloy.

Keywords:
Stress triaxiality; Lode parameter; Void; Ductile fracture; RVE; Aluminum die casting alloy

1. Introduction

Die casting process is characterized by forcing molten metal under high pressure into a mould cavity. Aluminum pressure die cast components are widely used in vehicle constructions due to lightweight requirements and economic benefits, e.g., reduction of production steps for complex components in one process (Sun et al. [1]). However, the complex geometries of die cast components with inhomogeneous microstructure and porosity make the analysis of damage behavior more complicated. Both the influence of stress state on damage development and the large scatter of local material properties have to be considered in the component simulation. A meaningful way for the consideration of the influence of die cast processes on local properties in the crash analysis is the coupling between casting simulation and crash simulation. For analyzing the failure behavior of casting components, it is important to consider the damage caused by initial porosity and the stress states leading to material softening and ductile fracture.

* Corresponding author. Ke-Shi Zhang E-mail: zhangks@gxu.edu.cn; Dong-Zhi Sun E-mail:dong-zhi.sun@iwm.fraunhofer.de
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