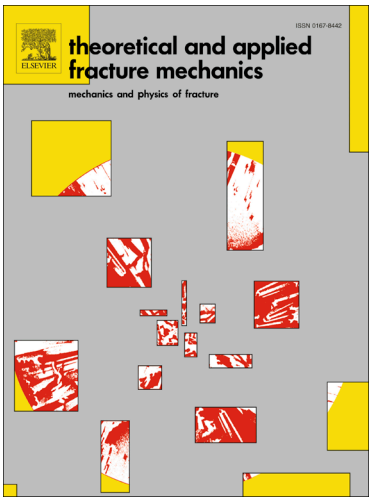

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PII: S0167-8442(17)30083-6
DOI: http://dx.doi.org/10.1016/j.tafmec.2017.05.015
Reference: TAFMEC 1867

To appear in: *Theoretical and Applied Fracture Mechanics*

Received Date: 24 February 2017
Accepted Date: 14 May 2017

Please cite this article as: N.A. Giang, M. Kuna, G. Hütter, Influence of carbide particles on crack initiation and propagation with competing ductile-brittle transition in ferritic steel, *Theoretical and Applied Fracture Mechanics* (2017), doi: http://dx.doi.org/10.1016/j.tafmec.2017.05.015

Influence of carbide particles on crack initiation and propagation with competing ductile-brittle transition in ferritic steel

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Abstract

Carbide particles play an important role for the fracture toughness of ferritic steels in the ductile-brittle transition (DBT) region as cracks mainly originate from a broken or debonded carbide. It is well-known that size, volume fraction, strength and distribution of carbides are relevant for the competition of ductile and brittle mechanisms of failure. In the present study, the influence of the carbide strength and carbide-ferrite interaction on the fracture toughness of ferritic steels is investigated in the DBT regime by a micromechanical, deterministic FEM model. The carbide particles are resolved discretely in the fracture process zone at the crack tip. Cleavage of ferrite, of carbides and debonding of the carbide-ferrite interface are modeled by cohesive zones. The simulated fracture toughness in the DBT region do compare well with experimental data from literature. Thus, the capability of the model is demonstrated to capture the competition of the various microscopic mechanism.

Keywords: Ferritic steel, Ductile-brittle transition (DBT), Fracture mechanics, FEM

Nomenclature

A	void nucleation pre-factor
A_0	radius of boundary layer
Δa	effective crack length
c_s	speed of shear waves
E	Young's modulus
f	void volume fraction
$\dot{f}_\mathrm{g}$	rate of void growth
$\dot{f}_\mathrm{n}$	rate of void nucleation
f_N	void nucleation constant
G_eff	effective shear modulus of homogenized material
G_m	shear modulus of ferritic matrix
G_p	shear modulus of carbide particle
J	J-integral

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