Effect of inclusion density on ductile fracture toughness and roughness

Three dimensional calculations of ductile fracture under mode I plane strain, small scale yielding conditions are carried out using an elastic-viscoplastic constitutive relation for a progressively cavitation solid with two populations of void nucleating second phase particles. Larger inclusions that result in void nucleation at an early stage are modeled discretely while smaller particles that require large strains to nucleate voids are homogeneously distributed. Full field solutions are obtained for eight volume fractions, ranging from 1% to 19%, of randomly distributed larger inclusions. For each volume fraction calculations are carried out for seven random distributions of inclusion centers. Crack growth resistance curves and fracture surface roughness statistics are calculated using standard procedures. The crack growth resistance is characterized in terms of both JIC and the tearing modulus TR. For all volume fractions considered, the computed fracture surfaces are self-affine over a size range of nearly two orders of magnitude with a microstructure independent roughness exponent of 0.53 with a standard error of 0.0023. The cut-off length of the scale invariant regime is found to depend on the inclusion volume fraction. Consideration of the full statistics of the fracture surface roughness revealed other parameters that vary with inclusion volume fraction. For smaller values of the discretely modeled inclusion volume fraction (≤7%), there is a linear correlation between several measures of fracture surface roughness and both JIC and TR. In this regime crack growth is dominated by a void-by-void process. For greater values of the discretely modeled inclusion volume fraction, crack growth mainly involves multiple void interactions and no such correlation is found.

General information
State: Published
Organisations: Department of Mechanical Engineering, Solid Mechanics, University of North Texas, Universite Pierre et Marie Curie, ParisTech
Contributors: Srivastava, A. K., Ponson, L., Osovski, S., Bouchaud, E., Tvergaard, V., Needleman, A.
Pages: 62-79
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Journal of the Mechanics and Physics of Solids
Volume: 63
ISSN (Print): 0022-5096
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 4.03 SJR 1.988 SNIP 1.83
Web of Science (2017): Impact factor 3.566
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 4.33 SJR 2.231 SNIP 2.107
Web of Science (2016): Impact factor 4.255
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 4.29 SJR 2.444 SNIP 2.154
Web of Science (2015): Impact factor 3.875
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 4.7 SJR 2.642 SNIP 2.319
Web of Science (2014): Impact factor 3.598
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 4.43 SJR 2.604 SNIP 2.256
Web of Science (2013): Impact factor 4.289
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 3.5 SJR 2.229 SNIP 2.054