Influence of Strain Hardening on Ductile Crack Growth under Small-Scale Yielding Plane Strain Conditions

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Abstract

The influence of strain hardening on ductile crack growth is investigated using a small-scale yielding finite element approach under plane strain conditions, incorporating *J2* plasticity and an advanced nonlocal Gurson model (1). High strain hardening exponents (n up to 0.5) are explored, extending beyond classical studies to include materials such as stainless steels, TRIP-TWIP alloys, and high entropy alloys. *J2* plasticity simulations reveal the impact of higher n on the finite strain zone, the opening stress distribution, and the crack tip opening displacement, providing insight into how strain hardening influences fracture toughness. Subsequently, Gurson-based simulations are conducted for varying values of strain hardening and initial porosity, generating *JR* curves, tearing modulus, and crack initiation metrics, such as JIC and critical crack tip opening displacement. These simulations demonstrate an increase in fracture toughness with higher n. We will address the following questions: (i) Why does fracture toughness increase with n? (ii) What is the effect of very large n on fracture resistance indicators? (iii) What is the potential impact of developing metallic alloys with high strain hardening capacity? Additionally, we emphasize the need for fine-tuning the Gurson model for high strain hardening exponents and establishing precise rules for mesh generation and initial crack opening to ensure accurate results. (1) Van-Dung Nguyen, Thomas Pardoen, Ludovic Noels, A nonlocal approach of ductile failure incorporating void growth, internal necking, and shear dominated coalescence mechanisms, Journal of the Mechanics and Physics of Solids, Volume 137, 2020, 103891, ISSN 0022-5096, https://doi.org/10.1016/j.jmps.2020.103891.

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