The Effect of Shear Contributions in Modelling Crack Tip Flipping

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ABSTRACT

Crack propagation in plate metals has recently been studied intensively for clues to why a slant crack, subject to far-field mode I loading, can display successive flipping of the crack face (from one 45-degree oriented shear band to the other). It has long been speculated if the out-of-plane plate deflection, originating from the slant crack configuration, could be the triggering mechanism for the phenomenon. In a very recent study, Nielsen and Hutchinson (2017) examines the slant crack problem, in both a purely elastic and an elastic-plastic model set-up, and their analysis clearly shows that a near tip asymmetry exists in the field quantities (effective stress, stress triaxiality, and Lode parameter) that control the ductile failure process. In fact, their study suggests that in the corner, where the slant crack intersects the outer free plate surface, the stress distribution appears to be consistent with the initiation of a re-oriented shear crack in the flipping direction.

Felter and Nielsen (2017) recently exploited the micro-mechanical based Gurson-Tvergaard-Needleman model (Tvegaard, 1990) to investigate whether it is possible that a prescribed out-of-plane action to a mode I crack can make the flipping engage – and it could, even without making use of any shear modifications to the Gurson material model. The question to be answered here is; *how will the shear contribution influence results?* Numerical investigations indicate that ductile failure is J3 dependent, and thus the Lode parameter (or the ω-parameter introduced by Nahshon and Hutchinson, 2008) is likely to influence results. In fact, it is expected to influence results in a positive manner regarding flipping as a slant crack growing at steady-state experiences zero Lode parameter in a direction consistent with the location where the flipping mechanism engages as shear-lips on the crack surface.

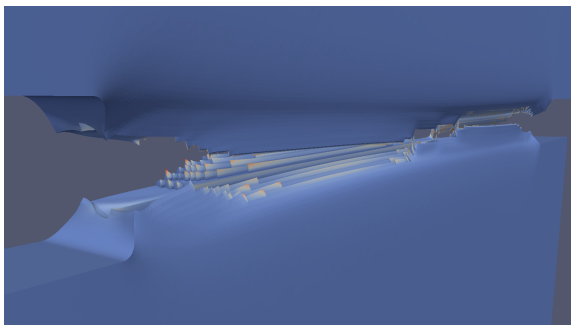

Figure 1: Double Edge-Notched Tensile test specimen subjected to combined Mode I and Mode III loading with $\omega=0$

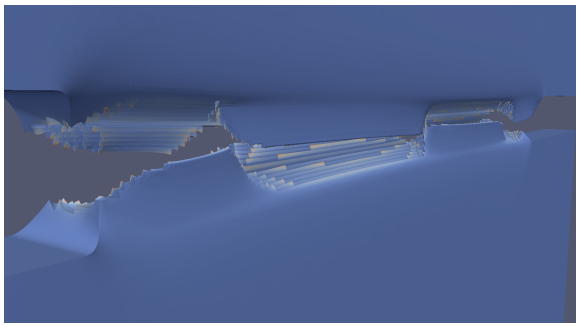

Figure 2: DENT specimen loaded as in Fig. 1, however, this time $\omega=1$

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