DUCTILE PLATE TEARING BY CRACK TIP FLIPPING

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ABSTRACT: Strong evidence exists that a number of unexplained transitions in crack surface morphology, that appears in mode I tearing of ductile plates, can be assigned to the so-called "crack tip flipping" mechanism, or element here of. But, little effort has been devoted to getting to the bottom of this intriguing plate tearing phenomenon despite numerous researchers reporting it. Crack tip flipping reveals itself when a slanted tearing crack, propagating in a ductile plate, shifts its orientation from one 45-degree angle shear band to the other. That is, the mechanics at play during crack tip flipping is strongly tied to the well-known slant crack propagation, where two equally active shear bands travel ahead of the leading tip, within a heavily strained region, such that plastic flow and damage evolution localize in one shear band and leaves the other band inactive. Figure 1 display a mode I crack that repeatedly flips back and forth in a very periodic manner and with high frequency – leaving a "shark teeth"-like surface. The flipping frequency is, however, dependent on the set-up (the constraints), the plate thickness, and plate material. High flipping frequencies are typical for steel, whereas the same tests performed on aluminum shows a lower flipping frequency. In fact, a slant crack can display flipping spaced apart on the fracture surface such that the slant crack has propagated some distance before making a new flip to the other 45-degree shear band. The mechanics involved are now understood to span multiple length scales – from the micro-mechanics governing ductile damage evolution, through the plastic flow localization into shear bands and thinning ahead of the crack tip, to the competition between the near tip plasticity and the far-field elastic plate response. A status on current insight to the crack tip flipping mechanism is given.

Figure 1: Repeated crack tip flipping in large scale testing of a normal strength steel plate subject to mode I loading.

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