Cohesive Zones and Interactions of Mixed-Mode Interface and Matrix Cracks

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Abstract: The heterogeneous state of stress in composite materials and the possible damage in interfaces, lead to a complicated problem concerning matrix crack tip loading analysis and crack path prediction. A powerful and accurate tool for calculating crack tip loadings is the J-integral, which was independently introduced by Rice and Cherepanov. The calculation of crack deflection angles using the J-integral criterion is enabled by the J-integral vector formulation, whereupon the calculation of matrix crack tip loadings and also interface crack tip loadings is possible. The J-integral and the crack tip opening displacement, as crack tip loading quantity of cohesive zone models, were related by Rice for the pure mode I loading case. In this work mixed mode loading conditions are considered, resulting in a generalization of the single mode I relation. The generalized relation is verified considering a Dugdale type crack under mixed mode loading. The formulation of a criterion for the transition of an interface crack to a matrix crack is also enabled by the generalized relation, resulting in a modification of the J-integral vector criterion of crack deflection. Numerical implementation of this criterion holds its own challenges concerning crack tip inaccuracy, where examples will be evaluated.

The interaction between a matrix and an interface crack is investigated too. On the one hand analytically by calculating the matrix crack tip loading in the presence of an interface crack using remote integration contours, revealing that the interface crack tip loading is included therein, on the other hand numerically by simulating growing matrix and interface cracks.