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SIMULATION OF DELAMINATION GROWTH IN LAMINATED COMPOSITES UNDER HIGH CYCLE FATIGUE USING A LEVEL SET MODEL

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Interface elements with a cohesive law are widely used for the simulation of delamination under quasi-static loading conditions. The interface element behavior is governed by a traction displacement curve defined such that the area under is equal to the critical fracture energy of the material. In recent years, researchers have tried to extend cohesive laws for use in high cycle fatigue analysis. However, basic concepts from fatigue analysis such as the notion that the crack growth rate is a function of energy release rate, can not be embedded in existing cohesive laws. Therefore, we propose a model in which the cohesive zone is eliminated from the computation.

The central idea is that the crack front location is described implicitly with a level set field and this field is updated according to the crack growth rate. The laminate is modeled as an assembly of sublaminates in both delaminated and undelaminated regions which are governed by the shear-deformable laminate theory. The total energy release rate as well as its fracture mode contributions are obtained using the stress resultant jumps across the configurational interface via a modified virtual crack closure technique (VCCT) [1]. Unlike the standard VCCT, this method does not require the crack front to be aligned with element edges. The velocity of the crack front is determined directly as a function of the energy release rate and the experimentally determined coefficients of the Paris relation of the material. This new model provides a more accurate extraction of energy release rates and contains an explicit relation between crack growth rate and energy release rate. Therefore, it is possible to reproduce the Paris relation that is given as input, something which cannot be achieved with existing cohesive methods. Furthermore, the present model allows for the use of elements that are larger than the cohesive zone [2].

To demonstrate the accuracy of the model, several tests under different modes of fracture are conducted and the results are compared with experimental data, analytical solutions

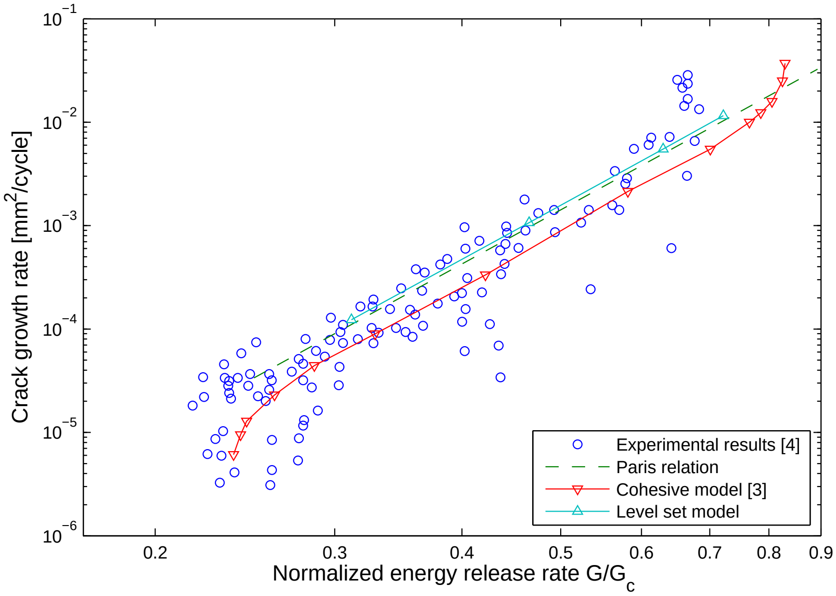

Figure 1: Comparison of numerical results for crack growth rate with experimental results and cohesive interface element results

and results from cohesive zone analysis. The crack growth rate for different ranges of normalized energy release rate under mode I is presented in Figure 1. The results from the level set model show a good agreement with experimental results and a perfect match with the Paris curve.

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