New insight into crack front segmentation into facets under mixed mode I+III loading: the role of T-stress and mode-dependent fracture properties

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Crack growth under combined mode I+III loading has been widely studied over the past decades since the pioneering works of Sommer [1] and Knauss [2]. Such a loading leads to a crack rotation around the direction of propagation in order to reduce mode III and reach a pure mode I situation, which is achieved by a fragmentation of the initial crack into multiple daughter cracks usually called facets. Once initiated, some of these facets grow and coalesce to form a stepped fracture surface becoming coarser as the crack grows. Several models such as e.g., [3], are able to capture the crack rotation from a macroscopic point of view. However, modelling the crack front segmentation into multiple daughter crack is still challenging. We previously proposed a model to study crack front segmentation into facets under mode I+III [4] based on a 3D application of the coupled criterion [5]. This model enabled crack initiation shape, orientation and spacing to be determined for any mode mixity ratio based on 3D finite element modelling of a periodic network of facets ahead of the parent crack. While the facet orientation and shape were determined based on a stress criterion, the initiation loading and facet spacing was obtained by coupling both stress and energy criteria. The proposed model is herein refined by considering both the influence of T-stress (parallel to the initial crack front) and mode dependent fracture properties. We show that considering exclusively either T-stress or mode dependent properties, facet nucleation may be more favourable than straight crack propagation but in conditions that are incompatible with experimental observations. It is only by coupling mode-dependent fracture properties and T-stress that it is possible to determine configurations compatible with experimental observations for which facet nucleation is more likely to occur than straight crack propagation. These configurations depend on the critical shear energy release rate and T-stress magnitude. We thus conclude that crack front segmentation into facets is loading and material dependent phenomenon that is not solely related to a mode mixity threshold but also to shear critical energy release rate and T-stress magnitude

References

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