Interaction of cracks with interfaces

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The interaction between cracks and interfaces plays a crucial role in the failure mechanisms of composite materials. Its analysis greatly differs from the conventional fracture mechanics. Moreover in addition to the mechanical loadings, the thermal residual stresses occurring after fabrication or in service have a particular influence. They are due to the elastic contrast between components together with the mismatch between the coefficients of thermal expansion. When present, they are often detrimental but can also sometimes enhance the resistance.

First, it is necessary to examine the initiation of cracks at stress concentration points on free surfaces at the end of the interfaces. It is the starting point of delamination which is the main failure mode of laminates. It can be carried out using either cohesive zone models or the coupled criterion. The main feature of both approaches, leading to similar results, is to use two parameters: fracture energy and critical opening, or fracture energy and peak stress, or any other equivalent pair of parameters.

The next step is to analyze the crack growth. It splits into two different cases according to the location of the primary crack.
The propagation of an interface crack, straight along this interface is quite well modelled but the conditions that govern the crack kinking out of the interface are not so properly established and it is observed that the T-stress plays a significant role in this kinking mechanism.
In the other case, the primary crack lies out of the interface and impinges on it. Then, either it crosses the interface and penetrates the next layer or deflects along the interface, or even as a particular case, the interface can prematurely debond while the primary crack tip is approaching the interface. The elastic contrast between the materials adjacent to the interface is a key parameter in the competition between the different mechanisms.
This second part is still analyzed using the coupled criterion or eventually cohesive zone models; there is no other way to proceed, the usual crack tip singularity disappearing in all these cases.