

Delamination of an adhesive joint by diffusion of a corrosive species

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Adhesive joints employed in shipbuilding, operating in aggressive environments, are often reported to undergo failure at the adhesive/substrate interface. Here, a fundamental study is presented on the diffusion of a corrodent from the side face of an adhesive joint to the intact adhesive/substrate interface, where the corrodent is consumed in a chemical reaction. Two diffusion paths are considered: the adhesive layer and a possible pre-existing interfacial crack. Delamination initiates at the tip of the pre-existing crack when a critical quantity of corrodent per unit area has reacted at the interface immediately ahead of the tip. This study focuses on the case where the delamination time is much larger than the duration of the initial transient to establish steady-state diffusion, such that the evaluation of the steady-state tip flux suffices to estimate the time required to debond the interface. Contour maps for the steady-state tip flux are given in terms of the non-dimensional groups entering the problem, and four regimes of behaviour are identified. In particular, one of these regimes presents a close analogy with a mode III elastic crack. Indeed, the problem of an embedded singularity within an outer singularity arises. An asymptotic solution for the steady-state tip flux is derived within this regime of interest, and this solution is in excellent agreement with the numerical solution of the full problem. Finally, the time-dependent diffusion equation is solved numerically, and the relevance of the steady-state assumption is assessed.

References:

A. Leronni and N. A. Fleck (2021), *Delamination of a sandwich layer by diffusion of a corrosive species*, submitted for possible publication.