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Damage Tolerance and Durability of Adhesively Bonded Composite Structures

Principle Investigator(s):

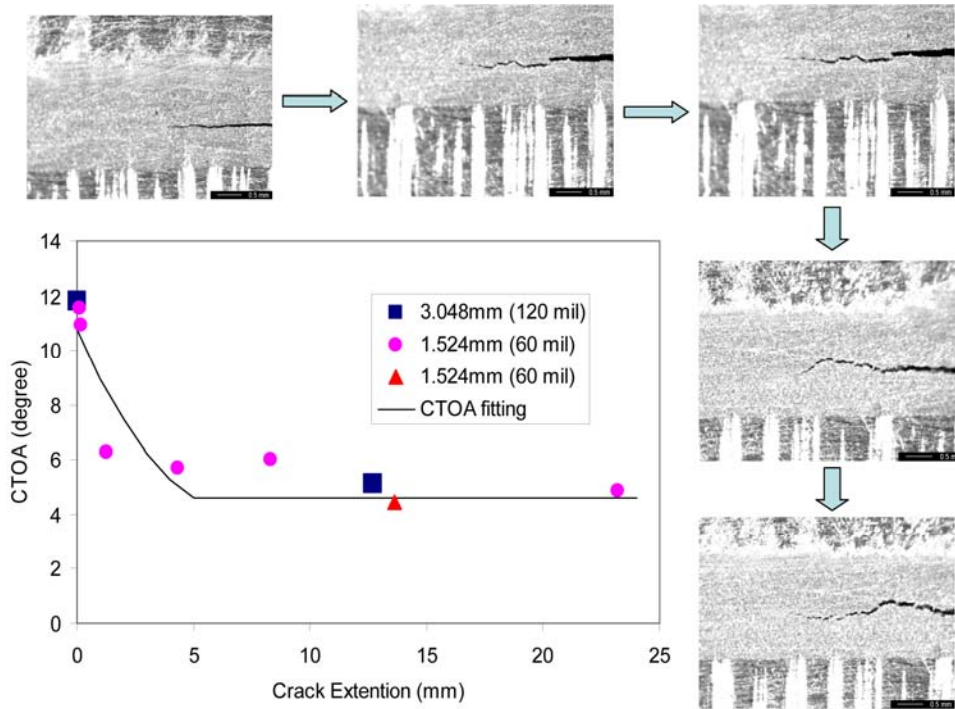
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Introduction

Significant amounts of composite materials will be used in new commercial jetliners such as Boeing 787 and Airbus 380, as well as in small and mid-sized aircraft. Many composite-to-composite and composite-to-metal components are bonded by adhesives, in both secondary and primary load-bearing structures. Failure prediction remains a difficult problem in composites and in adhesively bonded joints, and therefore the ability to definitively predict failure is a necessary technology that needs further research for obvious reasons related to safety, performance, and cost. Additional complexities arise when considering the durability of bonded composite structures: degradation of polymers (composite matrix and adhesive) can occur due to long-term environmental exposure, thereby negatively impacting the fracture and fatigue characteristics of these materials.

Objectives

The overarching objective is the investigation of the physical phenomena and processes that lead to joint failure, and the development of models describing these phenomena so as to make possible the prediction of the tolerance of bonded structures to damage, whilst accounting for bondline thickness variations and environmental effects. Research activity will be concentrated on three areas: (i) establishing a methodology for consistently relating the intrinsic material properties of adhesives in bulk and confined joint form, so as to define bondline-independent constitutive behavior, (ii) accounting for bondline thickness effects in the development of crack growth criteria which will be based on fracture mechanics and on cohesive zone modeling approaches, and (iii) investigating how varying bondline thickness interacts with moisture in the fracture behavior of adhesively bonded joints.



Crack-Tip Opening Angle Investigated as a Fracture Criterion Found to Be Independent of Adhesive Bondline Thickness

Expected Outcomes

The ultimate motivation for this activity is in response to the difficulty expressed by the end user community in the characterization of adhesive properties, and in particular the issue of thickness dependency and environmental effects. Therefore, it is expected that the end user community will be provided with useful tools that can be employed to interpret bondline thickness dependent test results, and to relate these results to the prediction of fracture in bonded joints. This has implications related to the amount of testing that is needed in order to characterize an adhesive system, as well as to certify adhesively bonded composite structures. Ultimately, bondline thickness can largely be eliminated as a test parameter over which data must be gathered, by the use of mechanics-based modeling, and thereby significantly reducing the amount of testing that is generally needed for measuring thickness and moisture content-dependent adhesive properties.