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Ultra-tough laminated metal composites based on aluminum sheets with optimal thickness engineered through adhesive bonding

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Extended Abstract

Abstract

Laminated metal composites (LMCs) are well known for their excellent mechanical performance, notably due to their ability to arrest crack propagating through the thickness of the laminate. When properly designed, a layered architecture can lead to an enhanced fracture toughness also in the transverse direction compared to a monolithic metallic sheet [1]. However, the respective contributions of the individual metallic layers, interface toughness and choice of thickness on the overall fracture resistance of metal laminates remain poorly documented. In this study, the fracture behavior of a multilayered aluminum stack assembled using conventional structural adhesives is investigated. Two adhesives are selected with different levels of fracture toughness. The laminates consist of multiple thin aluminum sheets bonded with uniform adhesive layers, without any interfacial architecture or additional toughening mechanisms. The adhesives are selected and processed to promote cohesive failure, ensuring that crack propagation and energy dissipation mechanisms are governed by the interaction between the aluminum layers and the bonded interfaces rather than by premature interfacial debonding. Fracture tests are conducted in the transverse, so called crack divider configuration, using Double Edge Notched Tension specimens (DENT). The fracture toughness of the individual aluminum sheets has been independently characterized under identical loading conditions exhibiting a clear thickness dependency [2]. The underlying hypothesis is that the apparent fracture toughness of the multilayered stack should be optimal when selecting the individual aluminum layers with a thickness corresponding the peak toughness and the right level of adherence. Further material selection analysis further highlights the interest of using multilayered aluminum systems with enhanced mechanical properties as a cost-effective alternative to more expensive bulk materials for typical industrial applications. Taken together, these findings provide a mechanistic interpretation of toughness enhancement in adhesively bonded aluminum laminates and establish a simple yet robust reference case for more advanced laminated systems incorporating interface architecture or tailored interfacial properties.

Keywords:

Multilayer Laminate Aluminum sheet Peak toughness Thickness dependence