Investigating the effect of thickness on the fracture toughness of thin metallic sheets focusing on Al2050

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Abstract

Fracture toughness is a critical parameter in material selection and structural design. For thin metallic sheets, fracture toughness is not solely an intrinsic material property but is also strongly influenced by sheet thickness. Previous studies have shown that fracture toughness increases with sheet thickness, reaching a peak at low thicknesses, and then decreases and stabilizes to a plateau in the plane-strain regime (1). However, the position and magnitude of this peak and the underlying mechanisms remain inadequately studied.

This study integrates both experimental and numerical approaches to address these gaps. The experimental investigations focus on aluminum alloy Al2050-T8, employing the Crack Tip Opening Displacement (CTOD) method on Double-Edge Notched Tension (DENT) specimens. A wide range of thicknesses is tested to accurately capture the influence of sheet thickness on fracture toughness and identify the critical peak.

On the numerical side, J2 elastoplastic simulations on both 2D and 3D frameworks are performed to establish reference solutions for the static case. Then simulations are performed using an advanced non-local Gurson–Tvergaard–Needleman (GTN) model, which incorporates mechanisms of void nucleation, growth, and coalescence. This model captures crack initiation and propagation in order to investigate the thickness-dependent trends in fracture toughness of thin sheets (2).

The study also investigates the role of strain hardening in influencing fracture toughness. While previous simulations relied on the Swift hardening law, this research implements the Kocks-Mecking strain hardening law, which accounts for four distinct hardening stages and is integrated into the GTN model to generate more realistic predictions.

References

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