← Strength and Stress-Strain States of Welded Joints and Structures

CRACK GROWTH IN THE HEAT-SEALED SEAM OF ALUMINUM - POLYMER LAMINATES FOR POUCH-TYPE BATTERY CELLS

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An analytical-numerical model is proposed for the slow subcritical growth of a crack in the heat-sealed seam of an aluminum-polymer laminate used in pouch-type battery cells under internal pressure. The internal pressure develops during battery charging and operation as a result of gas evolution. The enclosure of such cells should be treated not as a homogeneous metallic or polymeric plate, but as a thin asymmetric aluminum-polymer laminate consisting of an outer polyamide layer, an aluminum-foil barrier layer, an inner polypropylene layer, and adhesive interlayers. Particular attention is paid to the anisotropic, elastic-plastic, and viscoelastic behavior of the enclosure. Generalized stress–strain curves, a schematic assessment of creep, and an idealized bulging profile of the enclosure are presented.The crack-growth model combines a modified Leonov-Panasyuk-Dugdale scheme with a constant prefracture-zone length, a critical crack-opening-displacement criterion, hereditary viscoelasticity of the polymer layers, an exponential cohesive law for the seam, and degradation of the fracture energy under a sustained opening force. Cracks in heat-sealed seams may originate both during manufacturing and as a result of the opening force acting from the inner side of the cell. Under a sustained constant opening load, the maximum load-bearing capacity of the seam decreases, while the residual load-displacement response is adequately described by a modified cohesive law for the welded joint. Different temperature-time heat-sealing regimes and their influence on the fracture resistance of the seam are considered. Pouch cells were experimentally investigated under extreme charging conditions, with measurements of enclosure displacement. A relationship between internal pressure and displacement was established. Governing equations are presented for the incubation, transition, and steady crack-growth stages, together with an expression for the critical internal pressure.

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