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Some Observation Regarding Soft-Hard Laminates - Abstract

Invited talk

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Abstract

Tough Elastic Plastic Laminates through Instigated Strain Localisation

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Microprocesses during rupture of laminates are often correlated so that processes that lead to the rupture proceed in all layers at simultaneously. Some material layers are suppressed in their development to completed failure while other layers are forced to accelerate towards failure. In total, this synchronisation of the layers can give completely different mechanical properties of the laminate than what is expected from the mechanical properties of each separate layer.

This presentation describes what happens in a laminate consisting of layers of a stiff and brittle material laminated together with layers of a tough and weak material. The stiff and brittle material could typically be metal while the tough and weak material could be a polymer. The experimental results presented here are based on studies of a laminate consisting of an aluminium foil and a low density polyethylene foil (LDPE). Fracture mechanical testing were performed on the materials, both as laminates and as free-standing single layers. For the fracture mechanical testing pre-cracks with different lengths were introduced. Inspection of the broken cross sections shows that fracture occurs through necking, i.e., localised plastic deformation that lead to a decreasing and finally disappearing cross section.

The theoretical interpretation of the interaction between the laminate layers is reported in several publications from 2003 and onwards. The formulated theory is not limited to any particular material apart from two conditions. These are a) the laminate should combine stiff and brittle layers with weak and tough layers, and b) both materials should be susceptible to necking that propagates across the foil. The latter condition is not very restrictive since most elastic plastic materials fail through necking if they are thin, meaning for metals often sub mm thicknesses.

The key results are I) The ultimate strength increases to almost double of what is expected, while according to the theory it may be the sum of the two materials ultimate strength, and II) The energy absorption increases 2 to 3 times. The theory indicates that, with a clever design the increase is virtually unlimited.