Significant Results on Compressive Failure by Kinking

Using a video microscope equipped with microscope lens, we have recorded various stages of kink band formation and band width broadening in unidirectional fiber composites. These deformation modes are different from the commonly assumed kinematics employed by many investigators. The in-situ video pictures show that the early stage of kink band formation involves progressive, cooperative fiber bending/rotation and plastic shearing of the matrix within a shallow narrow band of about 10 fiber diameters wide. This deformation mode causes geometric softening of the material within the band. At some point in this process, fiber rotation within the kink band is halted. The termination of fiber rotation, referred to as fiber lock-up, is believed to be brought about by the stiffening of the composite shearing response at large shear strains. This forces the kink band to spread into the unkinked material (which is soft in shear) by band width broadening to accommodate the continuous overall end-shortening of the specimen. In the band broadening stage, the bends in the fiber (at the edges of the kink band) propagate into the unkinked material much like a pair of dislocations moving away from one another. Band widths of 30 to 50 fiber diameters with a steeper inclination than the initial band orientation have been observed. The final width of the kink band is set when the fibers snap. The mechanism of band broadening bears some similarity to neck propagation in certain polymers often termed ‘cold drawing’.

Based on our observations and theoretical studies, we presented arguments for two design approaches. The first is based on the peak stress and the second uses steady-state kinking stress [25, 26] as illustrated in the accompanying figure and text on page 5.
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[7] "Mixed-Mode Inelastic Crack-Tip Fields" Homogeneous Solids and Bimaterial Interfaces" (with S. Suresh) Scripta Metallurgica et Materialia, Vol. 25, pp. 1017-


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KINK BAND FORMATION AND BAND BROADENING IN FIBER COMPOSITES UNDER COMPRESSIVE LOADING

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Abstract—Various stages of kink band formation, propagation and band width broadening were recorded by a high resolution video camera. Based on these observations, the easiest modes of deformation have been identified and these form the basis of a new kinematic model for kinking. Theoretical predictions for kink band orientation and compression strength under steady-state band broadening are made. The conditions at incipient kinking and the incipient kinking stress are investigated. The relevance of the incipient kinking stress and the band broadening stress are discussed.

Fig. 7. Response of a “uniform specimen”; the incipient kinking stress and the band broadening stress are indicated. In specimens containing large geometric imperfections, the nominal peak stress drops significantly and can be expected to approach the stress associated with band broadening.