Matrix Damage in Carbon/Epoxy Composites

Matrix damage, involving transverse and shear cracks, is a common failure mode for composite structures, yet little is known concerning their formation or interaction. Results of pressure vessel tests, with differing bias fiber orientations, are presented. The results show that limit criteria, which are typically applied to fiber dominated failure, can also describe matrix damage. The results also show that after first ply failure, damage in the shear direction is akin to plastic hardening observed in metals while the transverse direction undergoes significant softening. While numerous models have been developed to describe the interaction of transverse and shear damage, there is relatively little experimental work in this area, particularly concerning shear damage. A modified losipescu coupon was designed to study the evolution of shear and transverse damage and their mutual effects. The layup and coupon geometry were selected in a way that controlled the severity of damage and allowed the measurement of shear and transverse stiffness degradation in the same coupon. The experimental results of the transverse and shear modulus reduction were compared with available material degradation models where damage was dominated by matrix failure. The comparison showed good agreement with existing models in the transverse direction; while in the shear direction, current models consistently overestimated the measured modulus reduction. The discrepancy in shear appears to be due to friction acting on the crack faces, which is not considered in current models.
Biosketch

Dr. Smith received his PhD from the University of Utah in 1994. He worked as a Post-Doctoral Fellow for two years at Oak Ridge National Laboratory before joining the faculty at Washington State University (WSU) in 1996. His research interests at WSU concern composite materials and sports science. His work in composite materials includes multi-axial testing, failure criteria, visco-elastic response, damage, processing, and environmental degradation. His work in Sports Science concerns sport ball impact, including the measurement and prediction of equipment performance and personal injury. He consults regularly for industry, primarily in the areas of predicting and measuring bat performance. He has advised the MLB and currently advises the ASA, NCAA and the NFHS concerning bat and ball performance matters. He chairs the ASTM subcommittee that is responsible for baseball and softball test methods. He is a member of the executive board of the ISEA (International Sports Engineering Association), and sits on the editorial board of the Journal of Sports Technology and the Journal of Sports Engineering.