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Interface Stress Field in Gradient Fiber-Matrix Interface

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Abstract

Damage initiation commonly observed at the fiber matrix interface is known to be due to the stress concentration attributed to the moduli mismatch between the fiber and matrix. The magnitude of such stress concentration is expected to be reducing by incorporating an interface layer of varying (gradient) modulus. The advent of inclusion of nano elements in composites now provides a mechanism of incorporating such gradient interface layer. In this work we have studied the distribution of interface stress field and its implication on the fiber-matrix failure initiation. Exact solutions are derived in this paper for the functionally graded multilayered isotropic elastic cylinder model. The solutions are obtained using the method of separation of variables and are expressed in terms of the summation of the Fourier series in the circumferential direction. While the solution for order n=0 corresponds to the axisymmetric deformation, that for n=2 includes the special deformation frequently utilized in the upper and lower bounds analysis. Numerical results for a three-phase cylinder with a middle functionally graded layer are presented for both axisymmetric (n=0) and general (n=2) deformations, under either the traction or displacement boundary conditions on the surface of the layered cylinder. The solution to the general deformation case (n=2) is further utilized to find the upper and lower bounds of the stress and strain field, as well as the effective shear modulus of the layered cylinder with a functionally graded middle layer, and these solutions can serve as benchmark examples in the future study of analyzing the influence of gradient interface on mitigating fiber-matrix interface damage.