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Thermal Response of Ceramic Matrix Nanocomposite Cylindrical Shells using Eshelby-Mori-Tanaka Homogenization Scheme

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Abstract:

We find thermal stresses developed in Ceramic Matrix Composite (CMC) cylindrical shells reinforced with aggregated Carbon Nanotubes (CNTs) with heat flux prescribed on the inner surface and temperature on the outer surface. Null surface tractions are prescribed on these two surfaces and the cylinder edges are clamped. The material properties are homogenized by using a two-parameter Eshelby-Mori-Tanaka (EMT) approach. Material properties of the ceramic are assumed to depend upon the temperature, and the smooth variation of the CNT volume fraction through the shell thickness is assumed to be described either by a sigmoidal function or profile-O or profile-X often used in the literature. The one-way coupled thermo-mechanical problem is analyzed by first numerically solving the nonlinear heat equation with the Generalized Differential Quadrature Method (GDQM), and then the linear mechanical problem by using Reddy's Third-order Shear Deformation Theory (TSDT) and the GDQM. For the same thermal boundary conditions and the volume fraction of CNTs, the maximum hoop, the in-plane shear and the transverse normal stresses developed in the cylinder are highest for the profile-X of CNTs. The aggregation factor noticeably influences the maximum transverse normal and the maximum hoop stresses developed in the cylinder.

Keywords: Ceramic-matrix composite; Carbon nanotubes, Two-parameter Eshelby-Mori-Tanaka scheme; Temperature-dependent properties; Sigmoidal power-law distribution; Third-order shear deformation theory.

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