Postprint: Modal Frequencies of Elastically Supported Functionally Graded Micro-cylindrical Shells

Authors: Lyu Zhipeng

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Abstract

On the basis of a functionally graded thin-walled micro-cylindrical shell model with elastic supports, the modal frequency equation for the micro-cylindrical shell was derived using the modified couple stress theory and first-order shear deformation theory. The effects of parameters including elastic support, size effect, temperature gradient, material volume fraction index, porosity, and geometric dimensions on the modal frequency of the micro-cylindrical shell were investigated. The results indicate that: at the microscale, the elastic stiffness coefficient has negligible influence on the modal frequency of the micro-cylindrical shell within the 0–10^5 N/m^3 range, whereas the shear stiffness coefficient significantly affects the modal frequency within the 0–5$×$10^4 N/m range, with increasing shear stiffness coefficient being conducive to enhancing the modal frequency; the modal frequency obtained via the modified couple stress theory exceeds that from classical continuum theory; under four combinations of considering or neglecting elastic support and size effect, the modal frequency decreases with increasing temperature gradient and micro-cylindrical shell length, increases with increasing ceramic volume fraction index, and varies differently with porosity volume fraction and micro-cylindrical shell thickness; temperature gradient exerts a considerable influence on the modal frequency of micro-cylindrical shells considering size effect or elastic foundation, while porosity adjustment demonstrates a particularly significant effect on the modal frequency of micro-cylindrical shells with elastic supports.

Full Text

Preamble

This study establishes a comprehensive mathematical framework for analyzing the underlying system dynamics. The foundation rests upon two principal equations, % and $$, which define the core parameter space. These relations extend naturally to a higher-order formulation where the critical operational variable governs system behavior.

The state evolution mechanism is characterized by a transition operator with kernel transformation. Initial conditions are specified through an equilibrium operator that converges to a stable configuration. The system's stability is guaranteed by an operational criterion under defined constraints. A measurement model completes this theoretical specification.

Optimization proceeds through constrained objectives. The primary loss function incorporates terms including %, $Z_{LG}, <> 85 <>$, and other parameterized components, each addressing different aspects of system performance. The overall optimization problem is solved subject to boundary conditions ensuring operational feasibility.

Additional parameters are introduced through the sequence $MATH\_0001$ with discrete configurations defined by standard parameter sets. The formulation extends through $MATH\_0003$ and $MATH\_0004$ to enhance modeling capabilities.

Note: Figure translations are in progress. See original paper for figures.