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Modeling aerothermoelastic properties and active flutter control of nanocomposite cylindrical shells in supersonic airflow under thermal environments

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Abstract

We examine the aeroelastic behavior of a cylindrical nanocomposite (i.e. CNT-reinforced composite) shell in a supersonic airflow under thermal environments. Meanwhile, using piezoelectric materials, active flutter control of the cylindrical nanocomposite shell is conducted. Reddy's high-order shear deformation theory is applied in the structural modeling, and the displacement fields of piezoelectric patches are derived according to the geometrical deformation relationship. The partial differential equation of motion is formulated by way of Hamilton's principle and then is discretized by the assumed mode method. The active controller is designed by the displacement feedback and linear quadratic regular (LQR) methods. The aerothermoelastic properties of the cylindrical shell are analyzed using the frequency-domain method. The flutter bounds of the cylindrical shell are computed using the third-order shear deformation theory (TSDT), and the first-order shear deformation theory (FSDT) is compared in order to verify the necessity of the high-order shear deformation theory in the vibration analysis of thick nanocomposite structures. The influences of temperature change, CNT distribution and CNT volume fraction on the aeroelastic stability of the nanocomposite cylindrical shell are investigated. The active flutter control effects of different control methods are performed. The influence of thickness of the cylindrical shell on the flutter control effects is examined.

Keywords: CNT-reinforced composite cylindrical shell; supersonic flutter; higher-order shear deformation theory; flutter control; nanocomposites

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