ANCF-Based Free Vibration Analysis of Functionally Graded Thin Elliptical Cylindrical Shells (Postprint)

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Abstract

The free vibration characteristics of functionally graded thin elliptical cylindrical shells were investigated using the absolute nodal coordinate formulation (ANCF) method. Third-order Bézier curve fitting technology was employed to calculate the initial circumferential tangent vectors and circumferential arc lengths of ANCF rectangular shell elements, thereby avoiding elliptical integral calculations and improving fitting accuracy. Starting from the kinetic energy expression and the functional relationship between the Green strain tensor and absolute displacements, the generalized mass matrix, generalized elastic force vector, and generalized stiffness matrix of functionally graded thin elliptical cylindrical shell elements were derived. Using d'Alembert's principle, a system of nonlinear dynamic differential equations was established. At the equilibrium position of the system, by introducing small variations in the generalized coordinates, a system of linear motion differential equations for functionally graded thin elliptical cylindrical shells was established. Through numerical calculations, the effects of gradient index, elliptical cross-section eccentricity, and length-to-diameter ratio on the natural frequencies of functionally graded thin elliptical cylindrical shells with simply supported ends were analyzed. The results show that the material's elastic modulus ratio, density ratio, and gradient index have significant effects on the natural frequencies; the natural frequencies of each order for stainless steel-alumina shells (with circumferential wave numbers 1~3) decrease with increasing length-to-diameter ratio; the natural frequency corresponding to a circumferential wave number of 1 increases with increasing eccentricity, and the length-to-diameter ratio is the main factor affecting the variation of natural frequencies.

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