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Vibration analysis of deploying laminated beams with generalized boundary conditions in hygrothermal environment

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Abstract

The free vibration of a deploying laminated beam in hygrothermal environment with a constant axial velocity is studied. The model of this system is given within the framework of the Euler-Bernoulli beam theory and von Karman nonlinear strain theory. The nonlinear dynamic equilibrium equation with generalized boundary conditions is established based on the Hamilton's principle with considering the combined effects of the axial motion, transverse vibration and hygrothermal environment. Based on the Galerkin method, a set of ordinary differential equations is obtained. The numerical results of the discretization equation are performed adopting the eigenvalue method and Newmark method. In addition, the dynamic stability is discussed, and extensive numerical calculations are performed to illustrate the effects of varying extension velocities, temperature, humidity and ply angles on frequencies.

Keywords: hygrothermal environment; axial velocity; deploying laminated beam

1. Introduction

Deploying structures, their length varies with time, are used in various industrial applications, such as elevator cables or hoisting system [1–6], satellite tethers [7], manipulators for industrial robot systems, drill-string systems in oil wells and so on. In addition, the vibration problems of these deploying structures have attracted the attention of many researchers. However, in previous studies, the materials of structure are basically homogeneous materials. But composite materials are gradually being applied to these structures, and it will be affected by hygrothermal environment. To improve the dynamic theory of deploying structures, the dynamic analysis of the deploying beam under hygrothermal environment is strongly demanded.

The analysis of the vibration characteristics of variable length structures (the change rate of the length is the axial velocity of the beam) can be traced back to 1972. Kotera [8] studied the

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