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Active H_∞ control of the vibration of an axially moving cantilever beam by magnetic force

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ABSTRACT

An H_∞ method for the vibration control of an iron cantilever beam with axial velocity using the noncontact force by permanent magnets is proposed in the paper. The transverse vibration equation of the axially moving cantilever beam with a tip mass is derived by D'Alembert's principle and then updated by experiments. An experimental platform and a magnetic control system are introduced. The properties of the force between the magnet and the beam have been determined by theoretic analysis and tests. The H_∞ control strategy for the suppression of the beam transverse vibration by initial deformation excitations is put forward. The control method can be used for the beam with constant length or varying length. Numerical simulation and actual experiments are implemented. The results show that the control method is effective and the simulations fit well with the experiments.

1. Introduction

Structures such as tapes, band saws, elevator hoist cables, and robot arms, steel strip from rolling machine and flexible tubes from aerial tankers can all be modeled as axially moving beams. These kinds of dynamic problems have been widely studied in the past 30 years. Zajaczkowski and Lipinski [1] and Zajaczkowski and Yamada [2] analyzed the dynamic stability of an Euler-Bernoulli beam under periodically sliding motion. Vu-Quoc L et al. [3] investigated dynamics of sliding geometrically-exact beams. Behdinan et al. [4] used non-linear theory to study the dynamics of flexible sliding beams and obtained some new formulae. Zhu and Ni [5] derived the energy and stability characteristics of translating beams and strings.

Lightweight and flexible structures often suffer from the drawback of large vibration due to low stiffness. Many researchers have set forth methods to solve the problem. Zhu et al. [6] used a pointwise control strategy to control the vibration of a beam with varying length under initial deformation excitations. Zhu et al. [7,8] researched the stability margin of the controller for the translating string and beam. Many researchers use piezoelectric systems for the vibration suppression or shape control [9–17]. But here we mainly concern about the control method by noncontact magnetic forces. Kojima and Nagaya [18] derived the time response of a cantilever beam with an iron tip mass subjected to an alternating electromagnetic force. Lu et al [19], Shih et al. [20], and Liu and Chang [21] studied the dynamics of a simply supported beam with a time varying axial magnetic load. Their results showed that the vibration of the beam can be controlled with a magnetic field of appropriate amplitude and frequency.

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