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Experimental study on dynamic characteristics of linear parametrically excited system

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An electromagnetic device, acting like a spring with alternating stiffness, has been designed to parametrically excite the cantilever beam transversely in the laboratory. It showed good potential for the experimental investigation of linear parametric system. Therefore, experiments for the natural frequency, the response (both free and forced) spectra and frequency response characteristics of a cantilever beam under electromagnetic excitation, are, respectively, conducted to study the dynamic characteristics of linear parametrically excited system. The vibrational model of the cantilever beam system is established using the assumed mode method. Theoretical results, related to the natural frequency, response spectra and external resonant condition, are presented to verify the experimental results. It is shown that the dynamic characteristics of linear time-periodic system do have some typical features, which differ distinctly from that of the linear time-invariant system.

1. Introduction

Dynamical systems mathematically modeled by linear ordinary differential equations with periodic coefficients (or Mathieu–Hill equations) are referred to as parametrically excited systems. This type of system is of great theoretical and practical importance because of its many applications in various fields of science and engineering [1,2]. In the dynamic analysis of parametrically excited system, some important aspects, involving the natural frequency, spectral properties of the system response and frequency response characteristics, have not gained sufficient attentions in current research [3]. For this reason, recent studies upon these aspects have been conducted, and some important theoretical results have been obtained by the authors [4–6]. These theoretical results should be verified by the experiment. However, the existing experimental studies, such as: beams and plates subjected to a periodic axial or in-plane loading [7–9], axial moving systems (belt [10,11] and plate [12]), focus on the actual systems with nonlinear characteristics, and the dynamic features induced by parametric excitation are not easy to be highlighted. Moreover, considerable investment in the hardware is required in order to achieve these experimental programs in the laboratory.

Fortunately, in 2001 and 2004, an electromagnetic device, acting like a spring with alternating stiffness, was developed in experiment by Yeh [13,14] to induce parametric excitation on cantilever beams. The amplitude and frequency of the parametric stiffness excitation were accurately controlled by the current flowing through the coil of the electromagnetic device. Yeh showed that the device could be easily equipped in the laboratory. Since the excitation force is a non-contact electromagnetic force which acts on the beam in the transverse direction, some nonlinear disturbances induced by the

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