Performance Improvement of Autoparametric Vibration Absorber by Eliminating the Viscous Damping and the Nonlinearity

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Abstract. Autoparametric vibration absorber attached to a main system is a type of equipment to reduce the resonance amplitude in the main system. In this study, the vibration absorber is primarily composed of a cantilever beam, and we improve the performance of autoparametric vibration absorber by the feedback control. By the position control of the fixed end of the cantilever beam, we decrease the viscous damping and change the natural frequency of the absorber. By performing the nonlinear analysis, we determine the suitable linear velocity feedback gain for reducing the amplitude of the main system. Also, when the amplitude of the absorber is relatively large, due to the nonlinear dependency of the natural frequency on the amplitude, the frequency ratio between the absorber and the main system is deviated from 1:2. We establish a nonlinear feedback control method to compensate for the nonlinearity so that the ratio maintains to be 1:2 regardless of the magnitude of amplitude. Furthermore, we conducted experiments using a simple apparatus. The results demonstrated the validity of the proposed control methods.

Introduction

Harmful vibrations caused by resonances are present in a wide variety of engineering dynamical systems. Dynamic vibration absorber [1] is a type of passive amplitude control system used in many industries such as automotive, construction and aerospace. It reduces the vibration of an object (main system) by vibrating a mass attached as a sub-system when the object is externally excited. Haxton and Barr [2] designed the autoparametric vibration absorber in which a cantilever beam with a mass at the tip is connected to a main system subject to external periodic excitation. Since then, many new devices have been developed to improve the performance of the absorber. An important aspect of this is the widening of the working band of the absorber. Cartmell and Lawson [3] widen the working band range by appropriately moving a lumped mass attached on the absorber. Then, the natural frequency of the abosorber is automatically tuned according to the excitation frequency so that the autoparametric resonance in the absorber is kept and the amplitude of the main system is reduced.

Results and discussion

In this research, in addition to expanding the working band rang like previous researches, we have further enhanced the vibration absorption at resonance point by means of feedback control. We propose an autoparametric vibration absorber in which the viscous damping and the natural frequency of the absorber can be reduced and changed, respectively, as shown in Figure 1(a). Under the absorber with feedback control, the amplitude of main system decrease with 83.5% at resonance point (It is 63.5% without feedback control) as shown in Figure 1(b). Moreover, when the amplitude of the absorber is relatively large, the frequency ratio between the absorber and the main system is deviated from 1:2 due to the cubic nonlinearity of cantilever beam. We propose a nonlinear feedback control method to compensate for the nonlinearity so that the ratio maintains to be 1:2 regardless of the magnitude of amplitude and it is experimentally verified.

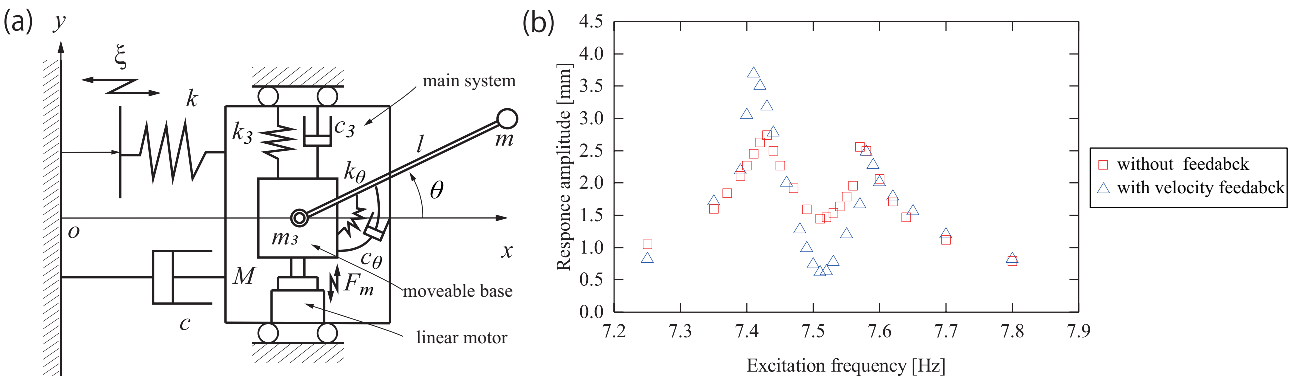

Figure 1: (a) Model of autoparametric dynamic vibration absorber. (b) Frequency response curves of main system.

References

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