Suppression of vibration transmission between oscillators coupled with a nonlinear inerter-based joint

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Abstract. This paper investigates the dynamic characteristics and vibration transmission behaviour of harmonically forced oscillators coupled via a nonlinear inerter-based joint based on a nonlinear inertance mechanism (NIM). The coupled oscillators represent simplified models for the dominant modes of engineering structures such as beams and plates, while the nonlinear-inerter-based joint fills in as the vibration transmission path between the two subsystems. The impacts of the nonlinear inerter in terms of vibration transmission are analysed for the modified design of suppression devices. The steady-state dynamic responses of the oscillators and vibration power flow between them are examined analytically. The steady-steady-state frequency response relationship and force transmissibility of the system are derived by the harmonic balance method.

Introduction

The inerter is a recently proposed passive mechanical element that can be used for vibration suppression purpose [1]. The forces applied to the two terminals of the inerter are proportional to the relative accelerations of the two ends, i.e., $F_b = b(\dot{V}_1 - \dot{V}_2)$, where F_b is the coupling inertial force, b is an intrinsic parameter of the inerter named inertance, $\dot{V}_1$ and $\dot{V}_2$ are the accelerations of the two terminals. Since the introduction of the inerter concept, some studies have been reported on the performance of inerter-based single degree-of-freedom vibration isolators [2] and dual-stage isolator [3]. As shown in Fig. 1, the NIM comprises a pair of oblique inerters with one common hinged terminal and the other terminals fixed, and it has been used for beneficial performance of nonlinear inerter-based vibration isolators [4]. The NIM can also be used for the design of structural joints between coupled systems so that the vibration transmission through the interface may be reduced. Fig. 2 presents a schematic diagram showing the use of the proposed structural joint with a NIM-based nonlinear inerter.

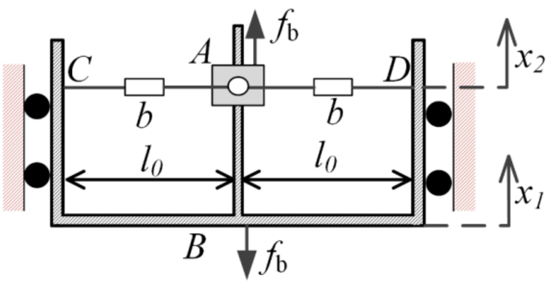

Figure 1: Configuration of a nonlinear inerter.

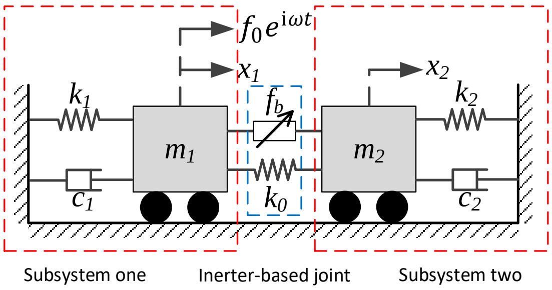

Figure 2: A schematic representation of the coupled oscillator coupled with a nonlinear-inerter-based joint.

Results and discussion

It is found that the use of the NIM within the joint can reduce force and vibration power flow transmission over a huge band of excitation frequencies. It is shown that the addition of the NIM can also introduce anti-resonances in the frequency-response curves and in the curves of the force transmissibility, in which the vibration transmission can be suppressed in specific excitation frequency range. It is found that the frequency response peaks of the integrated system bend towards the low-frequency range, similar to the characteristics of the Duffing oscillator with softening stiffness. These results demonstrate the potential benefits of employing the nonlinear inerter in vibration suppression and facilitate a better understanding of the effects of the NIM in the structural joint on vibration transmission.

References

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