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INVESTIGATION OF NONLINEAR ENERGY SINK FOR VIBRATION ABSORPTION BY MEANS OF HOMOTOPY ANALYSIS METHOD

Abstract

The working conditions of sensitive instruments and loads in spacecraft are affected by the complex and changeable dynamic environment, either directly or indirectly. Hence, effective suppression of unwanted vibrations from disturbances into a main system is a topic of special interest in aerospace engineering. Passive dynamic absorbers represent an interesting alternative.

It is only recently that the nonlinear strategy for vibration absorption has been widely investigated, one of the most well-known solutions is a Nonlinear Energy Sink(NES). An NES refers to a locally lightweight attachment that nonlinearly coupled to the primary structure via a strongly nonlinear stiffness and a viscous damping. According to recent studies, a one-way efficient spatial transfer of energy from linear primary structure to its nonlinear attachment can be observed in these strongly nonlinear systems under certain resonance condition. This phenomenon, which is conceptually referred in the literature as targeted energy transfer(TET), provides a fundamental theoretical support for broadband vibration suppression of structures using nonlinear systems which can never be possible in linear systems.

However, even a simple nonlinear system can possess very complicated dynamics, in most cases it is difficult to solve the nonlinear problems. One of the main challenges resides in developing a useful analytical method that could avoid all ad-hoc assumptions and reproduce the dynamics of nonlinear systems faithfully.

In this paper, the Homotopy Analysis Method (HAM) is presented for the vibration analysis of a 2-dof nonlinear system which consists of a linear primary structure and a nonlinear energy sink. Different from perturbation techniques, the validity of the HAM is not restricted to small parameters, thus can provide a powerful and easy-to-use analytic tool for nonlinear problems in general. Besides, compared to other analytic techniques, it provides us a simple way to ensure the convergence of solution, so that one can always get accurate enough analytic approximations.

To study its dynamics, the periodic solutions of the system with different excitation frequencies are analytically calculated by HAM. The result of HAM will then be compared to numerical methods including 4th R-K method and Incremental Harmonic Balance(IHB) method to verify its accuracy. Once the periodic solutions are determined, Frequency response can thus be naturally obtained, then the nonlinear vibration regimes will be studied. Efficiency of NES for vibration suppression will finally be investigated, and by varying the stiffness and damping, the optimal parameters will be given.