Optimal Design of Damped Vibration Absorber for MDOF Systems

B.P. Wang
Department of Mechanical and Aerospace Engineering
University of Texas at Arlington
Arlington, Texas 76019
Email: bpwang@mae.uta.edu
Phone: (817)272-2012(O), (817)272-2953(Fax)

Abstract

A generalization of the classical theory of damped vibration absorber (DVA) to MDOF system is presented in this paper. In the classical theory of DVA, it has been shown that when a damped vibration absorber is attached to a undamped single-degree-freedom system, there exist two frequencies at which the amplitudes of the response of the main mass are independent of the absorber damper constant. These frequencies are known as fixed point frequencies (FPF). Furthermore, for a given absorber mass, there exists an absorber spring constant so that the amplitudes of the main mass responses at the two FPF's have same value. This is called 'optimal tuning'. Finally, the optimal damper constant can be chosen by requiring zero slope at one of the FPF's of the amplitude of the response of the main mass in the frequency domain. In this paper, the classical results are generalized to the case for introducing a damped vibration absorber to a multi-degree-freedom undamped structure.The main results are summarized below:

1. For any response of the system that is linear combination of the system displacement, there exist fixed point frequencies (FPF) for arbitrary load distribution.

2. The FPF's are the square roots of the positive eigenvalues of a generalized eigenvalue problem. The matrices in the generalized eigenvalue problem depend on the mass and stiffness matrices of the undamped structure, the location of the absorber and the stiffness and mass of the absorber as well as the response of interest.

3. Optimum tuning can be achieved by adjusting the absorber spring to make the magnitude of the response at two specified FPF's the same. This can be accomplished by solving a 1-D optimization problem.

4. Optimum damping can be achieved by adjusting the absorber damper constant to make the slope of the magnitude of the response at a frequency zero. This can be accomplished by solving a 1-D optimization problem.

Detail derivations of the results will be presented in the paper. Several examples will be presented to illustrate the general results.