Hybrid Isolation of Structure-Borne Sound: Numerical Models

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Interior noise problems become more important due to the tendency to construct lighter vehicles. An important source for interior noise in a vehicle is the engine. The structural vibrations induced by the engine will transmit through the vehicle and will finally result in interior noise, so-called structure-borne sound. A method to reduce the interior noise is to isolate the engine with respect to the vehicle. This isolation can be passive, active or a combination of both called hybrid. A research project has been started in cooperation with TNO called hybrid isolation of structure borne sound. The project is splitted in two parts: One part of the project has the goal to investigate this type of isolation by means of numerical simulations, the other part deals with the design of demonstrators and practical implementations of hybrid isolation units. This presentation focuses on the numerical modeling approach for this type of problems.

Hybrid isolation consists of two types of isolation: passive isolation and active isolation. Passive isolation techniques are suitable for isolation of high frequency vibrations, while active techniques are used for the low frequency vibrations. To investigate the active isolation, a numerical model will be presented. This model consists of a structural and a bounded acoustic part that are representative for a vehicle. The responses of both parts are determined efficiently with modal superposition. The controller design is performed with the optimal control theory that is based on minimization of a cost function. Different cost functions will be compared with each other with emphasis on the performance of the structural related cost functions (e.g. minimization of structural velocities) in comparison with the acoustical cost functions (e.g. minimization of sound pressures).

The passive isolation is in practise realised by placing the engine on rubber mounts. The relatively non-stiff mounts cause a good isolation of the engine, especially at high frequencies. However, already at low frequencies the dynamic behaviour of rubber mounts may result in relatively stiff behaviour of the mount. This phenomenon will be illustrated by determination of the dynamic transfer stiffness of a rubber mount with the finite element method. The calculation is splitted in two parts: first a nonlinear static calculation is made to determine the relatively large pre-deformation due to the weight of the engine. After that a linear harmonic analysis is performed and superimposed on the pre-deformed mount. It is hereby assumed that the vibration amplitudes of the engine are sufficiently small to consider the kinematic and material response as linear perturbations about the pre-deformed state. It will be shown that the dynamic stiffness is strongly dependent on the frequency and pre-deformation. In some frequency ranges the mount will be considerable stiffer, resulting in decreasing isolation.

References:

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