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STRUCTURAL-ACOUSTIC COUPLED SYSTEMS WITH ACTIVE-PASSIVE DAMPING INTERFACE

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This paper presents some of the research activities carried out in collaboration with Roger Ohayon at the Structural Mechanics and Coupled Systems Laboratory of the Conservatoire National des Arts et Métiers in Paris. We propose to focus on appropriate finite element formulations for linear vibrations of elastic structures coupled with internal fluids, taking into account passive or active damping treatments at the fluid-structure interface for the noise and vibration reduction. Generally, active treatments, using for instance shunted piezoelectric devices, are effective in the low frequency range, while passive treatments, such as viscoelastic layers or porous insulation, are efficient for higher frequency domain. In all the analyzed formulations, the structure is described by its displacement field, while for the acoustic fluid, a scalar pressure field is chosen. Concerning the dissipative interface, various models are developed for vibration control. In this work we propose to analyze:

- The proper choice of state variables to model the damping interface;
- The symmetrization of the discretized coupled system;
- The development of appropriate reduced order models using modal projections.

For structural-acoustic problems with piezoelectric patches bonded or embedded in the structure, conservative formulations are extended in order to take into account electro-mechanical coupling. Appropriate choice of state variables has been investigated and leads to the introduction of very few discrete electrical variables in the variational formulation. It is shown that for most practical applications, one electrical unknown per patch (voltage or electric charge in one electrode), is sufficient to describe the multi-physics phenomena. The dissipation can then be controlled by adding a resistive or resonant electrical circuit connected to the piezoelectric patch. The resulting coupled electro-structural-acoustic finite element formulation can then be symmetrized and also reduced by projection on appropriate uncoupled modal bases leading to very efficient reduced order numerical models.

For passive interface damping in structural-acoustics, various models for viscoelastic and porous treatments are analyzed through appropriate finite element formulations. For example, when taking into account dissipative behavior through a local impedance constitutive relation, the problem becomes strongly frequency dependent. If a simplified but rather general model of Kelvin-Voigt type is used, the introduction of a scalar interface variable allows reducing the problem to a classical vibration damping problem which can be solved both in the frequency and time domains. This impedance model, although local, may represent satisfactorily a porous layer. Various viscoelastic interface models, using for example fractional derivative constitutive equations, are also analyzed and the associated finite element and reduced order models are developed in the frequency and time domains.

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