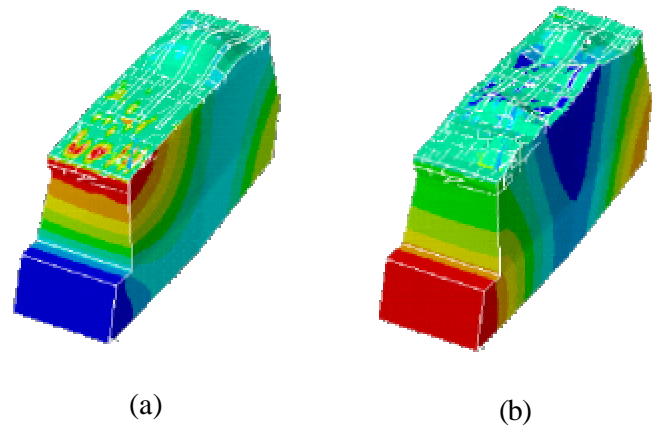


Vibroacoustic Modeling Using Modal Coupling Method

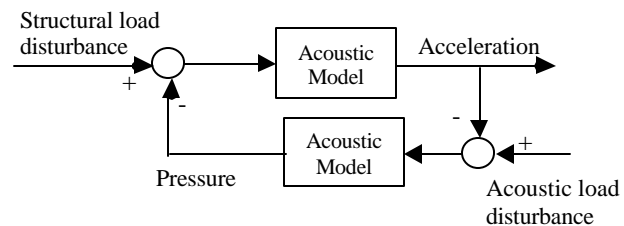
Analytical techniques are used for modeling of vibroacoustic systems with simple geometries such as parallel wall enclosures. For more complex systems, numerical modeling techniques based on Finite Element (FE) and Boundary Element (BE) formulations, are used for prediction of the vibroacoustic behavior of such systems. These modeling methods cover from simple purely acoustic models to fully coupled vibroacoustic models, incorporating the interaction between the acoustic field and the vibrating structure at the mesh interface. This interaction causes the acoustic pressure to exert a force to the structure and the structural motions produce an effective “fluid load.”

Figures (a) and (b) depict the pressure distribution for the 2nd and 3rd modes of a vibroacoustic system comprised of an enclosure with a flexible roof. The roof is modeled as a flexible structure. The model was developed to study the low frequency attributes of the cavity acoustics. The absorption capability of absorptive materials, e.g., wall linings, is frequency dependent. The absorption coefficient of such material are measured experimentally and used as the material property of the acoustic elements at the fluid-structure interface in the finite element model



Many acoustic problems are solved by performing harmonic response analysis, which evaluates the pressure distribution in the fluid due to a harmonic load at the fluid-structure interface. This is done over the frequency range of the load. Depending on the range and the resolution of the frequency, harmonic analysis can be very computationally intensive. A computationally inexpensive method is being used at DEICON which constructs the vibroacoustic model of a system allowing for high-speed frequency response (analogous to harmonic response) as well as other systems related analyses. This method expresses the vibroacoustic system in terms of the uncoupled modes of the fluid and the structure. Although this approach is not new but the modern computer software tools such as Matlab®/Simulink® have made its use very straightforward and effective, especially in designing sound control applications.

This modeling method is based on formulating the modal parameters of the cavity with rigid walls and the structure with no fluid interaction, i.e. in-vacuo. Having the uncoupled modal models, the rigid wall cavity and in-vacuo structural modal are coupled, “in modal domain”, in a feedback manner; see the adjacent figure.



In addition to being computationally efficient modal coupling analysis offers a very convenient platform, especially in block diagram based modeling softwares such as Simulink®, for synthesis and analysis of active sound control in vibroacoustic systems. It allows for easy access to acoustic (pressure) or structural (acceleration/strain) variables for feedback or feedforward control purposes using structural (force/moment) or acoustic (volume velocity) for actuation.