Recent advances in numerical simulation to predict interior noise for full vehicle applications

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Abstract:

This presentation will give an overview and describes a number of recent advances in the prediction of interior noise with a focus on automotive and ground transportation area.

At low frequencies, the response of a system is typically dominated by a small number of modes; standard analysis methods based on finite elements, boundary elements and infinite elements typically provide an accurate description of the response.

At high frequencies, such methods are seldom practical. The reasons are twofold. Firstly, the number of degrees of freedom required to describe the response becomes intractable at higher frequencies. The second, more fundamental problem, however, is that the higher order modes of a system tend to be particularly sensitive to small perturbations in the properties of the system. Small uncertainties in the geometry, material properties and boundary conditions of a system can lead to large uncertainties in the dynamic response. A statistical description of a system becomes essential in order to draw meaningful conclusions about the response.

The transition between the low frequency region where the system have a fully deterministic behavior driven by global modes and the high frequency region where the behavior of the system can be accurately described by averaged and statistical parameters, is the so-called the medium frequency range. This region may be more or less large according to type of structure and the type of excitation.

The paper will focus on recent advances in low and medium frequency ranges and will present some effective application.

In the low frequency domain, a particular focus will be attached to recent advance in numerical simulation in order to accurately describe the effects of trimming package when predicting the interior acoustic level, for automotive applications. Such complex component is often made of porous-elastic material which, in the low frequency range, affects both damping and absorption. In the last decade, the use of detailed finite element model to accurately predict these two effects had become possible thanks to significant increase in CPU and memory capabilities and the development of High Performance computation (HPC). The paper will present the recent advance in this field and will describe a sub-system-based approach allowing computing the low frequency response of fully trimmed car in up to 500Hz.

This frequency range overlap the lower part of the medium frequency range where part of the structure becomes statistically dispersive. The behavior of this part is mainly driven by local modes which makes the Statistical Energy Analysis (SEA) based approach well adapted. However, in the medium frequency range, part of the structure may still have very low flexibility which, in from statistical-energy-flow point-of-view, may introduce a strong indirect coupling between subsystems that have a large number of local modes. A simple representation of this kind of behavior may be given by two flexible plates connected by a stiff beam. The frequency range where the beam has only few global modes and the plates have a large number of local modes is typically a medium frequency range. In order to predict vibration and/or acoustic response in this frequency range, an innovative approach has been developed during last decades and lead to breakthrough for the numerical

simulation of vibroacoustic behavior in the medium frequency range. This new multi-domain approach allows to combine and fully-couple FE and SEA in one single model. SEA is used to statistically describe high modal density subsystems while FE is used to describe the low modal density part in a deterministic way.

This so-called « Hybrid » approach is demonstrated to be very efficient for structure-born noise analysis as such component of interior noise require an accurate modeling for both structural vibration and radiated noise.

All these new modeling approaches are now available in the commercial software VA One which offers a suite of fully coupled solvers in a single environment allowing to build a virtual prototype and to predict its vibroacoustic behavior using the right and most appropriate approach according to its actual physical behavior and the accuracy needed by the design process.