11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

COMPUTATION AND OPTIMIZATION OF FULLY COUPLED 2D VIBROACOUSTIC WAVE'S DISPERSION: APPLICATION TO NOISE CONTROL

Manuel Collet[2], Morvan Ouisse[1], Mohamed Ichchou[2]

[1] FEMTO-ST, ENSMM, 24 chemin de l'Epitaphe, 25 000 Besançon, France, morvan.ouisse@univ-fcomte.fr

[2] LTDS, CNRS, Ecole Centrale de Lyon 36 av Guy de Collongue, 69134 Ecully, France, manuel.collet @ec-lyon.fr

Key Words: *Metacomposite, adaptive vibroacoustic, impedance optimization, waves propagation*

Research activities in smart materials and structures are very important today and represent a significant potential for technological innovation in mechanics and aerospace. In order to implement new vibroacoustic functionalities inside complex coupled fluid/structure system, new technologies are now available which allow integration of dense and distributed set of smart materials, electronics, chip sets and power supply systems for implementing distributed control strategies. It is also possible to develop the next generation of smart "composite" structures also called adaptive metacomposite. By using such an integrated distributed set of electromechanical transducers, one can imagine to attain new desired acoustic dispersion and scattering that can allow the control of mechanical or acoustic flow in a large frequency band.

Tailoring the dynamical behavior of wave-guide structures can provide an efficient and physically elegant approach for optimizing mechanical components with regards to vibration and acoustic criteria, among others. However, achieving this objective may lead to different outcomes depending on the context of the optimization. In the preliminary stages of a product's development, one mainly needs optimization tools capable of rapidly providing global design directions. Architectured materials and other adaptive or smart systems are employed to improve the vibroacoustic quality of structural components, especially in the Low Frequency range even if distributed transducers are used. Recently, much effort has been spent on developing new multi-functional structures integrating smart cells systems in order to optimize their vibroacoustic behavior over a larger frequency band of interest. For medium and high Frequency band, metacomposite concept also appears as a very efficient way for reaching optimal vibroacoustic functionalities.

This concept couples two different aspects in vibration control. The first concept is connected to periodic structures theories usually connected to metamaterial developments. In this case, it is well known that the dynamic behavior is fully connected to periodicity ratios and existing pass bands and blocked bands can be of real use in vibration control. The second concept is associated to vibration control by using multi-physical coupling. For example, shunted piezoelectric smart materials are employed for the metacomposite achievement by integrating into the metamaterial electronics and numerical components allowing implementation of adaptive and controlled behavior. We also tend to extend the notion of programmable matter to vibroacoustic programming composite. First application of these concepts has been already done for controlling mechanical energy power flow or by processing acoustic radiation effect.

In this paper, we present an integrated methodology for optimizing vibroacoustic energy flow in interaction between an architectured metacomposite made of periodically distributed cells incorporating holes in interaction with an open acoustic domain. Extension of shifted cell operator methodology to fluid-structure interaction is presented. The computation of interacting Floquet-Block propagators is also used to optimize vibroacoustic indicators as noise absorption and emission depending on holes design. The main purpose of this work is first to propose the numerical methodology to compute the fluid-structure multi-modal wave dispersions with grazing flow asymptotic impedance. In a second step optimization of holes topology is used to control the acoustic power flow.