Theoretical and experimental analysis of vibro-acoustic couplings at high levels: application to the design of passive absorbing devices

Oscillation mitigation of a primary resonator based on an additional secondary system is a widespread concept frequently used in industry. These devices are also applied on acoustic resonators presents in ducts, for transport or building engineering applications. They aim at reducing noise, which is a major societal problem whose impact on public health is regularly recalled by the World Health Organization. In confined spaces, treatments based on absorbing materials are effective and inexpensive in the medium and high frequencies of the audible range, i.e. above 250 Hz. A technological issue still holds at low frequencies, where existing solutions are often cumbersome, expensive, or effective in a tiny frequency range.

Among different strategies, the possibility of taking advantage of the nonlinear behaviour of the secondary element has been the subject of various studies in the last two decades. The interest relies in the passive character of the absorbing device. The efficiency of this energy pumping method was shown in the case of mechanical resonators designed as soft and viscoelastic membranes that exhibit large displacements. The resonance can be tuned in this case at a frequency close to that of the targeted acoustic resonator. The pumping mechanism emerges from a combination of complex energy transfers, which still need to be clarified in order to quantify the absorption performance and optimize the design for specific applications. In particular, the internal resonance 1:1 denotes the energy exchange phenomenon resulting from the nonlinearities between two oscillators located at close frequencies: this regime arises from a bifurcation whose theoretical and experimental identification presents difficulties. A problematic also relies in the characterization of energy transfer from the primary resonator frequency band to the higher part of the spectrum, which is in particular found in the Duffing oscillator. Quantifying the input acoustic levels needed to actuate these different energy transfers is a key point of the analysis.

A first objective of this PhD thesis concerns the characterization of these different transfers based on a cross-analysis between theoretical predictions and experiments: specific methods from non-linear dynamics will be applied in this part. A second objective is to test absorbing devices that involve porous membranes and their modellings. Different strategies for designing acoustic membranes and resonators for specific applications can be studied in a third part of the thesis.

Keywords

Acoustics, Vibro-acoustics, Structural dynamics, Nonlinear dynamics, Energy transfers

Host institution and laboratory

Université de Technologie de Compiègne, Roberval Laboratory, Acoustics and Vibrations group

Supervision and contacts

Arthur Givois, lecturer
Nicolas Dauchez, professor

Profile requested

Graduate of master of research or engineering school
Knowledge of acoustics and structural dynamics
Skills in mechanical modelling, numerical and experimental methods
Research experience in a laboratory and/or research and development team
A curiosity for original physical phenomena is encouraged

A CV and application letter should be sent to Arthur Givois (arthur.givois@utc.fr)