Improving the efficiency of identification of mechanical and coupling parameters of porous materials by sensitivity analysis

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The study of porous materials is becoming of great interest in the context of noise control. They are widely used in vibro-acoustics for many applications and reasons. Their low cost and good performances in terms of noise attenuation or dissipation of energy impact, justify its wide use in the transports industry. In this work, a contribution to the identification of material parameters is proposed, by combining an optimization procedure together with a preliminary sensitivity analysis.

Modelling porous materials appears as an important challenge for optimal design. However the behaviour of these materials involves many mechanical and coupling modelling parameters. Their knowledge is fundamental for obtaining reliable models allowing efficient design procedures. This article presents a study conducted in order to improve their identification. The method associates a preliminary parameters sensitivity analysis with an optimisation study. The global sensitivity analysis of the outputs of interest is done using the FAST method [4]. The sensitivity analysis is then used to improve the optimisation of parameters values by readjusting analytical results over experimental measurements. We also present the results and benefits of the methodology coupling parametric sensitivity analysis and optimal updating technique.

The models used to describe the behaviours of porous materials require knowledge of many parameters. In general, 5 to 9 parameters are used in most popular models like Johnson-Allard and Biot-Allard [1, 2]. These models couple a fluid phase with a solid phase and can be used in an analytical analysis for simple cases or in finite element models. The parameters studied here are the mechanical parameters, namely the Young's modulus (E), Poisson's ration (ν), loss factor (η) and density (ρ), and the coupling parameters, resistivity (σ), tortuosity (α_∞), viscous and thermal characteristic length (Λ and Λ') .

The complexity to determine experimentally these parameters led us to look for a way to identify their values with satisfactory accuracy to allow efficient design studies. An analytical model was used to calculate the absorption coefficient ('α') and the acoustic impedance ('Z') for the considered material (melamine foam). This model is based on the Biot-Allard theory [1, 2], whose analytical results can be compared with those obtained experimentally by use of an impedance tube. A parametric optimization [3], was used to

select parameter values in order to adjust the values and matching the best analytical curves with the experimental data.

In this work we have tried to take advantages of a preliminary sensitivity study of parameters to be able to identify parameters values from simple measures, without implementing a complex experimental methodology for each parameter. The sensitivity study will provide important information toward their influence over the results we are looking for. The method used to study Biot-Allard sensitivity model is the FAST method (Fourier Analysis Sensitivity Test) [4].

The parameters sensibilities of porous materials in acoustics performances depend on frequency and parameter studied. A sensitivity study of coupling parameters on acoustic performance of porous materials with rigid frame has been proposed in [5], using the methods Sobol and FAST. Based on these studies, we did a sensitivity analysis using FAST method for melamine foam. This allowed us to classify the parameters in a way we can organize and optimize the suite according their sensitivities.

Several simulations were done to determine the best methodology to take advantages of a preliminary study of sensitivity in the identification of mechanical and coupling parameters of porous materials. We found results that give us benefits of a fairly simple method improving computing time.

References:

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