Transmission loss: sensitivity analysis

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Noise reduction is a particularly important issue in the aerospace industry, as the very harsh acoustic environment inside the launcher may damage the payload, especially at lift-off. In order to optimize the noise level inside the payload cavity of a launcher, it is important to study the acoustic transmission through the fairing in a broadband frequency range. The launcher fairing can be modelled as a composite cylindrical shell enclosing an acoustic cavity. The resulting model depends on many different and independent design parameters, such as materials and geometry. At early design stages, these parameters can vary in broad design ranges. In order to reduce the number of parameters of the model, it is therefore needed to identify the most influential ones.

Global sensitivity analysis techniques have been developed for addressing problems with a large number of inputs with broad ranges of variation, but have seldom been used in mechanical design yet. The FAST (Fourier amplitude sensitivity test,see [1]) has been applied to study absorption and impedance models of poroelastic sound absorbers [2], but no results concerning global sensitivity of vibroacoustic models are to be found, to the authors' knowledge. An interpretation of global sensitivity analysis results for sound transmission through structures is proposed in this work.

The FAST method is then applied for each frequency band. This method gives two indices for each input parameter of the model: the main effect (or first-order sensitivity index) and the total sensitivity index. The former is a the share of the variance of the model that is removed when the considered parameter is set to a fixed value. The total sensitivity index (TSI) is the sum of the contribution of the parameter in all its interactions with other inputs. As a consequence, a parameter can be neglected and its value fixed if its TSI is low; whereas it will be the only important parameter in a given frequency range if its main effect is close to 1. The difference between TSI and main effect is an indicator of the presence of interactions between parameters.

Figure 1 shows the results for a simple model of acoustic transmission through an infinite isotropic plate [3] with parameter values varying in the ranges specified in table 1. The classical interpretation of this vibroacoustic behaviour distinguishes a *mass law* in the low frequency region, a stiffness-controlled behaviour in high frequencies, and a damping-controlled region around coincidence. These different behaviours can be observed on the curves in figure 1. Coincidence and resonance regions can be identified by the high level of interactions between parameters. Similar conclusions are drawn for composite plates and shells models.

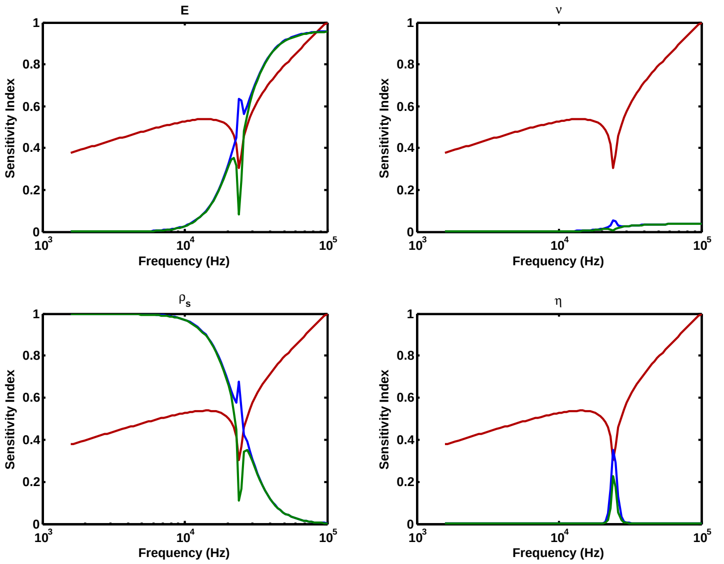

Figure 1: Sensitivity analysis results for infinite plate impinged by a 45^o oblique plane wave. Red: STL trend for steel plate. Green : main effect. Blue: total sensitivity index

Variable	Min. value	Max. value
E (GPa)	1.8e11	2.2e11
ν	0.27	0.33
ρ_s $(kg.m^{-3})$	7020	8580
η	10^{-3}	$5 \cdot 10^{-1}$

Table 1: Variation ranges of parameters for isotropic models

References

[1] Andrea Saltelli, Stefano Tarantola, and K. P.-S. Chan. A quantitative model-independent method for global sensitivity analysis of model output. *Technometrics*, 41(1):39–56, 1999.

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[3] L. L. Beranek. *Noise and vibration control*. McGraw-Hill, 1971.