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Parametric approaches for uncertainty propagation in SEA

Antonio Culla [a], Walter D'Ambrogio [b,*], Annalisa Fregolent [a]

[a] Dipartimento di Meccanica e Aeronautica, Università di Roma La Sapienza, Via Eudossiana, 18 - I-00184 Roma, Italy
[b] Dip. di Ingegneria Meccanica, Energetica e Gestionale, Università dell'Aquila, Via G. Gronchi, 18 - I-67100 L'Aquila (AQ), Italy

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ABSTRACT

A limit of statistical energy analysis (SEA) is that of providing only the mean values of the mechanical energy of a vibrating system. In this paper, the variability of SEA solution under uncertain SEA parameters (coupling loss factors, internal loss factors and injected powers) is investigated by comparing a sensitivity approach and a design of experiment (DoE) approach. Uncertainties of the SEA parameters depend on uncertainties in the physical properties of the considered mechanical system. Numerical results are derived using a benchmark structure made by three aluminum plates with a common junction and a launcher fairing. The analysis of the effect of uncertainties of SEA parameters can be used for design purposes, i.e. to identify which are the most effective areas to modify in order to control the energy level of a given subsystem.

1. Introduction

In statistical energy analysis, the studied systems belong to a random population of similar systems [1,2]. Systems are considered similar if their physical parameters are slightly different. SEA considers a structure as the union of several subsystems. Each of them is a modal group, i.e. a set of similar modes. For instance, considering two plates welded together, six modal groups can be identified, one set of flexural modes and two sets of in plane modes for each plate.

SEA estimates the mean value of the energy stored in the modal groups constituting the studied system. The mean value provided by SEA equations is in principle the average response of a set of similar systems. However, SEA equations are represented by a linear system of equations for each frequency, or better for each frequency band. The solution of each linear system gives the energy of each subsystem in a given frequency band. No average operation is explicitly performed, but all the statistics is not visible to the user. In general, this is not a problem because many simple relationships used by physicists and engineers are the result of more complicated mathematical procedures. Unfortunately, in this case this simple model holds only under many strong hypotheses, listed in Section 2.

The linear system results from some mathematical manipulations, that include also averages on frequency bands, on the classical equations of motion of multi-degrees of freedom systems, and the observance of the strong hypotheses mentioned before. The coefficients of the linear system, named coupling loss factor (CLF) and internal loss factor (ILF), are the result of these average processes and account for the parameters of the native physical system [3]. Therefore, SEA gives the energy of each modal group belonging to the studied system. This energy is the most representative sample of a statistical population of similar systems and on a frequency band. No information is given about the dispersion of the data around the result. In order to provide a true statistic solution it is necessary, at least, to know the variance of the result.

* Corresponding author. Tel.: +39 0862 701 865; fax: +39 0862 701 979.
E-mail addresses: antonio.culla@uniroma1.it (A. Culla), walter.dambrogio@univaq.it, dambro@ing.univaq.it (W. D'Ambrogio), annalisa.fregolent@uniroma1.it (A. Fregolent).

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