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NUMERICAL VALIDATION OF RADOM ENERGY FLOW ANALYSIS FOR COUPLED BEAM STRUCTURES BASED ON FEA AND SEA APPROACHES

Abstract

Random energy flow analysis (REFA) is an analysis tool that models the mid-to-high frequency dynamic behavior of structural/acoustical systems under random excitations, which has the portential of being extensively applied in the spacecraft industry. The method is recently developed based on the conventional energy flow analysis (EFA) method. In this paper, REFA is applied to a three-dimensional frame structure that is subject to stationary random broadband disturbances taking into account the energy transmission and reflection effects in the structure, and the validity of the method is investigated. The average energy responses, which include the energy density distribution as well as the lumped total energy of all wave types that can arise in each beam member of the frame, are predicted using REFA. The random vibration analysis of the structure is performed with conventional finite element analysis (FEA) using very dense mesh as well, where the energy responses are obtained based on the solved vecolicty distributions. The validity of REFA in predicting random energy responses for complex built-up beam is investigated through comparisons between results of the energy approach and FEA soluitons in consecutive bands covering a wide frequency range.

From the energy density distribution results in a specific frequency band, it is observed that REFA solutions for the flexural energy fields reflect well spatially smoothed representation of those from FEA that display significant spatial variation, and that REFA solutions for longitudinal and torsional energies are very close to the averaged energy fields obtained using FEA. The conventional statistical energy analysis (SEA) is also employed to estimate the response of the structure in all frequency bands, where only the lumped energy stored in each wave field can be calculated. Direct comparisons are made with respect to the energy solutions, which provide the basis to compare the reliability of REFA and SEA in response prediction. For all wave fields of the structure in relatively higher frequency range, REFA predictions domonstrate a good agreement with the FEA results. However, from solutions of SEA, it is observed that this approach can only provide energy estimates of satisfactory accurary for some wave fields and for other ones considerable errors always exist in the predicted resutls, which increase as frequency. This demonstrates the less reliability of SEA compared with REFA for the frame analyzed, which can be attributed to the failure of some assumptions involved in SEA and the avoidance of them in REFA.