Vibration reduction analysis for hybrid metal-composite structure with material selection optimization approach

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ABSTRACT

The power flow method for structural dynamic response analysis and optimization is of significance. Power flow level difference, a new evaluation method, can describe vibration energy distributing and attenuating discipline in the continuous structure’s system under external loading. Considering the vibration level difference and power flow level difference, the power flow is defined as the evaluating criterions of reduction in this paper. According to the stacking sequence hypothesis of metal material, the mechanical parameters of the material and layers number are defined as design variables, and the mathematical model of structural dynamic optimization based on material selection optimization theory is established. Finally, the naval hybrid steel-composite mounting structure for example, the structural dynamic optimization design problem with multi-variables and constraints is presented. By introducing multi-island genetic algorithm, the optimization problems are solved. The numerical calculation shows that the vibration response of the hybrid metal-composite structure can be reduced by using material selection optimization method. The paper provides an effective and feasible method to solve the problem for multi-material distribute optimization.

KEY WORDS: material selection optimization; hybrid metal-composite structure; power flow level difference; vibration level difference; genetic algorithm (GA).

INTRODUCTION

Noise and vibration control is becoming more and more important in engineering design and manufacture. For the structural vibration problem, it is more overall and efficient based on energy analysis concept. The power flow is a parameter to describe energy intensity, which can deals with the amplitude and phase relationship between the force and velocity of the vibration reference points. Power flow analysis (PFA) method is an effective simulation tool to predict dynamic response behavior of the vibration systems. Power flow level difference, a new evaluation method, can present vibration energy distributing and attenuating discipline in the continuous structure system under external loading. The vibration power flow approach is applied to analysis the compressor system, the power flow transmission path is discussed, and the frequency characteristics of the vibration power flow to the receiver structure are compared (Lee et al, 2004). The vibration beam-plate system has been produced in order to study the distribution of vibration energy and energy flow in beams, rods and plate under simple but realistic excitation condition is discussed (Pavić, 2006). The higher-order vibration theory is implemented in the sandwich configured floating raft vibration isolation system with an equivalent mobility based power flow progressive method (Choi et al, 2009). The power flow of the submarine floating raft vibration system was analyzed, and it shown that the power flow parameter could estimate the isolation system better than the vibration acceleration parameter (Xu et al, 2012). The vibration isolation system is divided into substructures, and the average vibration energy theory is adopted as an objective function, in which the power flow optimization method is used to deal with the passive vibration isolation system (Xiao et al, 2011). A new kind of finite element method was proposed for investigating the characteristic of the vibratory power transmission of the complex floating raft system (Zhang et al, 2008).The damping structure of submarine raft is optimized by using the vibration power flow calculation approach based on component modal technique in the environment of iSIGHT software platform (Wu et al, 2006).

The composite material has excellent mechanical characteristics with low density, high damping and specific strength, and so on. Many works have done about the composite laminated in dynamic response problem. For the composite materials optimization, material selection optimization (MSO) could do with the materials conversion in the optimization process, the materials conversion between the composite material with non-composite materials, and the materials conversion between different kinds of composite material. The main advantage of reliable materials selection is take advantage of best mechanical behavior of each material-candidate in a structural under given load and boundary conditions. Different glass/carbon ratios and stacking