Analysis of radiation efficiency and sound transmission loss of functionally graded plates using the state space method

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Abstract

This study examines the radiation efficiency (RE) and sound transmission loss (STL) of flexible finite functionally graded material (FGMs) plates in an infinite rigid baffle. FGMs are composite materials engineered to possess heterogeneity by continuously varying the composition of the constituent materials in a chosen direction. Such customization makes FGMs highly suitable for designing vibro-acoustically efficient structures. Accurate modeling analysis of the multiphysics response of FGM structures is challenging. First, the effective material properties of these materials have to be estimated by either using a simple rule-of-mixtures approach or more complex elasticity or numerical models. The radiation efficiency of FGM plates under harmonic force and sound transmission loss of the plate under oblique incident acoustic waves are analyzed. Acted load vibrates the plate and radiates sound. The state space formulations for plate vibrations are derived from the full three dimesional equations of motion, stress-strain, and strain-displacement relations (1). An elementary radiator approach solves the Rayleigh integral that links the plate velocity to the radiated pressure waves. Radiation efficiency represents the actual sound power radiated by the plate compared to an ideal vibrating piston. Sound transmission is quantified by the ratio of transmitted to incident sound power. Yang et al. (2) investigated only the sound power level for an FGM plate using the state space method. This implementation is validated through comparisons with existing literature.
The radiation efficiency (RE) and sound transmission loss (STL) of functionally graded (Al/Al2O3) plates simply supported on all edges is presented in this work for different power law variations of the material properties. As the FG layer's power law index rises, it is seen that the RE curves exhibit a declining tendency. The STL curve may have three separate stiffness, mass, and damping control areas, respectively. A detailed study of the effects of plate thickness, plate aspect ratio, damping, load type, and incident angle on RE and STL is presented.

References

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