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MULTI-MATERIAL STACKING SEQUENCE AND FIBRE ORIENTATION OPTIMIZATION OF VIBRATING LAMINATED COMPOSITE PLATES FOR MINIMUM SOUND EMISSION

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Summary: Composite materials like fibre reinforced polymers (FRPs) are being used increasingly in aerospace vehicles, maritime carriers, wind turbine blades, where high strength, high stiffness and low weight are important properties. In such applications, the FRPs are usually stacked in a number of layers, each consisting of strong fibres bonded together by a resin, to form a laminate. In addition, laminated sandwich structures may also consist of layers made of foam material. When these composite structures are used in dynamic environments, vibration control and noise reduction become of great technical significance. In this lecture, this design objective will be considered in the form of minimizing the sound radiation from a laminated composite plate. This is accomplished by optimizing simultaneously the laminates in terms of proper choice of material, stacking sequence and fibre orientation. Such advanced optimization has only recently become possible via development of the novel, so-called method of Discrete Material Optimization (DMO).

In the lecture, the vibration of the laminated plate is assumed to be excited by time-harmonic external mechanical loading with prescribed frequency and amplitude, and the design objective is to minimize the total sound power radiated from the surface of the laminated plate to the surrounding acoustic medium. Instead of solving the Helmholtz equation for evaluation of the sound power, advantage is taken of the fact that the surface of the laminated plate is flat, which implies that Rayleigh's integral approximation can be used to evaluate the sound power radiated from the surface of the plate. The DMO method for simultaneous optimization of the fibre angles, the stacking sequence, and the selection of material for laminated composite plates is then presented, and several numerical examples are shown in order to illustrate the approach.