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Rapid vibro-acoustic optimisation of laminated composites

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Abstract: Light and stiff composites such as fibre-reinforced plastics are sensitive to propagate structure borne sound but simultaneously offer a wide range of adjusting the material behaviour. Thereby, stiffness and damping of such composites are contradictory material properties related to the fibre orientation. Commonly, the composite design is based on FEA simulations requiring special modelling efforts. In contrast, the multi-dimensional optimisation of a laminate with numerous layers of different materials and orientations requires very fast numerical solutions for numerous repetitions. In this study, a complex but efficient vibro-acoustic model is presented. The FEA is extended by a strain energy based modal damping approach for the layerwise accumulation of the anisotropic damping. In addition, the radiated sound power is determined by a velocity based approach directly on steady state simulations of the structure only avoiding a complex multi-physical modelling. Moreover, the frequency dependent radiation is consolidated to a single scalar optimisation objective using a fast and efficient semi-analytic approach. Therefore, analytical formulations of amplification factors of the modal power contributions are introduced. This efficient simulation methodology is further applied to design a vibro-acoustically optimised composite part. The achieved results emerge the vibro-acoustic optimisation potential of thermoplastic composites compared to a steel reference case by material substitution only as well as an additional laminate optimisation.

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