Control of Lamb wave modes with surface-mounted resonators

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Lamb waves in plates and their analog in pipes enable long-range volumetric inspections and inspections of otherwise inaccessible material domains. However, the multimodal nature of Lamb waves in plates can significantly complicate the required processing and analysis of received signals for nondestructive inspections. Researchers have proposed various signal processing methods for multimode wave packets as well as different ways to preferentially generate a single mode with varying degrees of success. In this work we demonstrate that surface-mounted resonators enable control of the fundamental Lamb modes at low frequencies and we interpret the results in terms of modified boundary conditions. In fact, it is known that rod-like resonators mounted on the surface of a plate forbid propagation of the fundamental A0 mode. However, beam-like resonators mounted on the surface of a plate and designed using analogous principles do not forbid propagation of the fundamental S0 mode. Finite element simulations confirm this experimental finding. An explanation for how resonators control the propagating modes in a plate based on the boundary conditions is posited. In essence, the presence of the resonators must mimic the specific homogeneous boundary conditions, which are not the traction-free boundary conditions, in order to effectively couple the resonators to the plate. Experiments on plates with resonators designed using this philosophy and having sub-wavelength spacing show that propagation of the fundamental S0 Lamb mode is severely limited. These results could have profound effects on guided wave sources in terms of mode control.