(368)

Hybrid Ray-FDTD Model for the Simulation of the Ultrasonic Inspection of CFRP Parts

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Carbon Fiber Reinforced Polymers (CFRP) are commonly used in structural parts in the aeronautic industry, to reduce the weight of aircraft while maintaining high mechanical performances. Simulation of the ultrasonic inspections of these parts has to face the highly heterogeneous and anisotropic characteristics of these materials. To model the propagation of ultrasound in these composite structures, we propose two complementary approaches. The first one is based on a ray model predicting the propagation of the ultrasound in an anisotropic effective medium obtained from a homogenization of the material. The ray model is designed to deal with possibly curved parts and subsequent continuously varying anisotropic orientations. The second approach is based on the coupling of the ray model, and a finite difference scheme in time domain (FDTD). The ray model handles the ultrasonic propagation between the transducer and the FDTD computation zone that surrounds the composite part. In this way, the computational efficiency is preserved and the ultrasound scattering by the composite structure can be predicted. Inspections of flat or curved composite panels, as well as stiffeners can be performed. The models have been implemented in the CIVA software platform and compared to experiments. We also present an application of the simulation to the performance demonstration of the adaptive inspection technique SAUL (Surface Adaptive Ultrasound).