Title: Ultrasonic Defect Detection in Thick Composites With Out-of-Plane Waveness

Abstract:

Thick composites (usually thickness > 10 mm) are increasingly applied in aerospace engineering and prone to out-of-plane waviness in the manufacturing process. Besides the drastic decrease of compressive strength due to out-of-plane waviness, local resin rich regions may also exist in the composite, both perplexing the ultrasound propagation therein. In this study, a multi-frequency ultrasound-based method is proposed to characterize both waviness and delamination. Numerical modeling with frequency sweeping is conducted first, to quantitatively analyze influence of waviness and local resin rich region on ultrasound propagation in pulse-echo mode. It is found that at the resonance frequency corresponding to single composite ply, ultrasound B-scan built from signal phase can well characterize the waviness. And ultrasound with a lower frequency, compared with the ply resonance frequency, enables more energy to penetrate the local resin rich region and propagates with minor wave vector deviation through the wavy region. Then, a two-step composite characterization method is proposed. In the first step, ultrasound with frequency corresponding to the ply resonance is used to characterize waviness, and in the second step, ultrasound with a lower frequency is generated to detect delamination within wavy composite based on reflected wave signal. With this method, defects can be detected in the coexistence of waviness and local resin rich region. Finally, experimental validation work is performed, showing the method is promising in detecting defects.

Keywords:
Out-of-plane waviness | Delamination | Ultrasound defect detection | Thick composite |