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Enhancement of the Total Focusing Method Imaging for Immersion Testing of Anisotropic Carbon Fiber Composite Structures

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Carbon fiber composite structures are becoming more important in the construction of aerospace structures and other industries because of their low weight and their remarkable mechanical properties. Hence, master these structures from conception, during and after their manufacturing, represents an important issue in NDE. The control and the repair of these advanced materials require an in-depth knowledge of composite structures and the reliable detection of defects like delaminations, inclusions, porosities and stacks of resin, is increasingly important. In the present work, such defects are imaged with the Total Focusing Method (TFM) associated with a ray-based model that takes into account the directional dependence of ultrasonic velocity in an anisotropic carbon fiber composite.

This study is conducted with simulations and experiments in an immersion testing configuration and for carbon fiber composite structures with different types of symmetry (orthotropic, transverse isotropic...). First, the anisotropy effects on the TFM images are studied by assuming an isotropic homogeneous medium in the wave propagation model. Then, this anisotropy is taken into account in the imaging algorithm in order to correct the defect location errors on one hand, and to reduce the scattering noise on the other hand.

In both figures below (Figures 1 & 2), the TFM images are calculated in an anisotropic carbon fiber composite structure with orthotropic symmetry including five artificial delaminations. The results highlight a significant improvement of the image quality when the anisotropy is taken into account in the focusing algorithm.

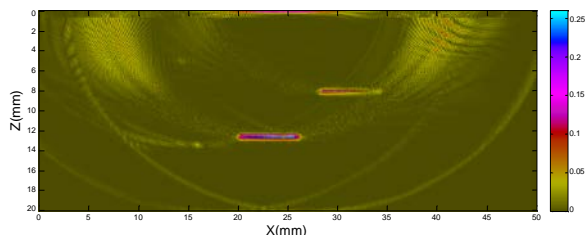


Figure 1. Conventional TFM image assuming wave propagation in isotropic medium.

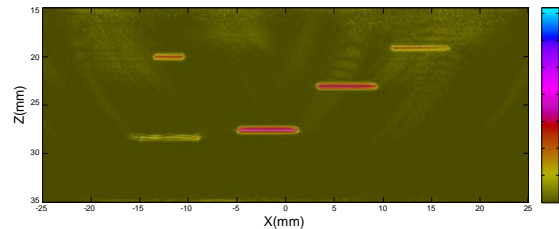


Figure 2. New TFM image when the anisotropy of the material is taken into account.

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