Advanced Methods of Nondestructive Inspection of Composite Structures Pertinent to Aerospace Industry Based on Limited-Angle X-RayComputed Tomography

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Aerospace composite parts are more susceptible to variations in manufacturing processes compared to metal parts. The effects of inadequate design method and manufacturing process used to produce Carbon/Epoxy and Glass/Epoxy composite aircraft fatigue-critical, flight-critical components, result in defects such as combinations of fiber waviness and porosity/voids, with a significant risk to impact the residual capability and the useful life of these components. Accurate measurements of manufacturing defects are essential for assessment of the effects of the defects strength and fatigue performance of composite structures.

This work presents some of the most recent technology advances that lead to development of new methods for nondestructive inspection and structural diagnostics of composites. The main focus is the assessment of the possibility for breaking through the current limits of X-ray Computed Tomography (CT) in order to enable high-fidelity nondestructive inspection (NDI) of large aerospace structures. Currently, strict limitations related to generating X-ray projections all around the inspected object in a full CT scan, prohibit CT application to large structures. The commercial industrial CT systems utilize full 360° projection angle range for high-quality 3D reconstruction of the inspected objects. The ability of the software methods used in such systems to reconstruct the details of the inspected object often becomes unacceptable as soon as the range of projection angles decreases below 180°. A high-fidelity CT inspection based on a Limited Angle Tomography (LAT), less than 180°, range of projection angles is essential for enabling CT inspection of large structures.

![Image of Glass/Epoxy flapping element. 3D view of the clamped area and close-up cross sections of the seeded void and X/Y sections of close-up 360° and LAT scans.](image)

The algorithms used in the existing commercial CT reconstruction software need to be improved by using iterative stochastic reconstruction methods and physics-based system modeling. Enabling technology presented in this work has a strong potential for providing the basis for a reliable and cost-effective structural design methodology for aerospace industry.