

Non-destructive evaluation of embedded out-of-plane fiber waviness in composite materials

Michael Thor¹, Patrick Insamer¹, Jürgen Gruber², Günther Mayr², Roland Markus Hinterhölzl¹, Markus Günter Ronny Sause³

¹Lightweight Design and Composite Materials, University of Applied Sciences Upper Austria, Austria,

¹Josef Ressel Center for Thermal NDE of Composites, University of Applied Sciences Upper Austria, Austria, ¹Institute of Materials Resource Management, University of Augsburg, Germany

Fiber waviness can be considered as one of the most significant manufacturing effect that occurs in composite materials, due to the severe knockdown effect on the mechanical properties, such as stiffness, strength and fatigue and therefore dramatically reduces the load carrying capacity of the material. Wavy plies can appear in arbitrary shapes and locations. The decision, if these irregularities are considered as manufacturing features, respectively effects, or as defects, is dependent on the size, number and location of the effects on the component. The assessment of out-of-plane fiber waviness in composite materials is strongly dependent on the accuracy of detection and quantification of the wave parameters such as amplitude, wavelength and position in the laminate. In aviation industry, ultrasonic testing is the state-of-the-art method for the evaluation of composite materials. The evaluation of the ultrasound signal from different manufacturing effects is difficult and it often cannot be clearly decided whether there are actually wavy regions in the laminate or not. In this work, various applied non-destructive evaluation (NDE) methods, such as infrared thermography, shearography, eddy current, digital image correlation and computed tomography have shown great potential for the detection and characterization of embedded out-of-plane fiber waviness in composite materials. These methods were applied on test plates with artificially embedded waviness with varying amplitudes, wavelengths and positions in the laminate and assessed in view of accuracy. These experimental methods were accompanied by finite element simulations.