Understanding and modelling of the effects of out-of-plane waviness defects on the mechanical performance of a thermoplastic matrix laminate

Soutenance de thèse de Claire FOUGEROUSE
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Abstract

This Ph.D. thesis (CIFRE ONERA with funding from AIRBUS Operations) focuses on the out-of-plane waviness manufacturing defect generated in specimens of composite laminates composed of unidirectional plies with carbon fibres and a thermo-plastic matrix. The effects of the defects on the mechanical performance were studied for tensile and compressive loads.

Out-of-plane waviness was artificially generated in the specimens during the manufacturing process. Optical observations on the specimen edge were carried out prior to the tests to analyse the defect morphologies. An experimental campaign on specimens with and without defects was carried out with multi-instrumented tests. It revealed a stiffness decrease, differences in damage scenarios (notably earlier crack and delamination initiation) and a failure stress reduction in the presence of a waviness.

In parallel, finite element models were developed to refine the understanding of the effects of defects. For this purpose, a digital twin was generated for each specimen based on optical microscope observations of the defect geometry carried out before the tests and on the basis of a parametric description of the defect. With a continuous damage model, the simulations revealed a local reduction of the elastic properties close to the maximum waviness and a significant knock down on the failure stress in relation to the severity of the defect. The model qualitatively captured the damage scenario of the experiments. Finally, a numerical strategy based on metamodelling was proposed to analyse the influence of each geometrical parameter of the defect on the mechanical response and to propose a fast estimate of the defect-induced knock down factors according to its geometry.

Key words: Thermoplastic matrix laminate, effects of manufacturing defects, experiment-modelling comparison