Production-based Multi-criteria Design Optimisation of an Unconventional Composite Fuselage Side Panel by Evolutionary Strategies and a Surrogate Model of Manufacturability Analysis

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1. Abstract
This paper introduces a novel multi-criteria optimisation framework that efficiently combines manufacturing analysis of composite structures with respect to various production criteria such as manufacturability and limitation of process-based material deviations. These criteria include gaps induced by fibre placement systems as well as structural constraints regarding material failure, stability and damage tolerance. Within this optimisation framework, evolutionary algorithms are coupled with an in-house parametric FE-Model generation tool, which exhibits an extensive design scope comprising various unconventional stiffener topologies, evaluates buckling modes and obtains composite specific failure criteria according to multiple load cases.
This work focuses on multi-criteria optimisation of a newly developed lattice-stiffened fuselage panel with novel double-curved stiffeners aiming for minimum weight based on a reference structure. Composite related design parameters such as number of layers and orientations of fibres are efficiently optimized in conjunction with a wide range of geometric parameters by applying a layup table based strategy regarding manufacturable layup combinations.
Within the optimization framework, an interface to the production concept is introduced, which evaluates quantitative information based on manufacturability analysis and estimation of tow gaps according to geometric topology of the stiffeners regarding machine parameters of AFP system. In context of the investigation manufacturability outputs are approximated using radial basis functions in order to increase the optimization efficiency in terms of computation time. Both structural responses and manufacturability values of the each individual are converted into one fitness value generated by the in-house evolutionary algorithm. This fitness evolution leads to more efficiently producible unconventional configurations and adequate mechanical performance with significant weight savings and limited material deviations based on production criteria at the each new generation.
Main characteristics of the optimized new panel are respectively, adaptation of the unconventional stiffener topologies to various loading conditions and innovative window configurations offering considerably large space. The final design is compared with an optimised reference composite panel with the same weight objective under identical loading conditions.