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Optimisation of multi-layered structures using a multispecies genetic algorithm and high-order structural models

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Due to the intrinsic nature of aerospace engineering, structural weight has always been an aspect of utmost importance during the design stages of aircraft and spacecraft. Indeed, light alloys were preferred for the construction of such structures until the irruption of composite materials. Currently, composite materials might represent more than 50% of the structural components of aircraft thanks to its mechanical properties and improvements in manufacturing techniques. In the recent years, fabrication procedures have been oriented to the additive manufacturing strategies, such as automated fibre placement or fused deposition modelling, which lead to multi-layered structures. As mentioned before, weight optimisation is one of the key steps in structural design. However, nowadays procedures, such as polar [1] or lamination [2] parameters, are based on assumptions that may shrink the design space. In this work, a direct optimisation genetic algorithm (GA) [3] is proposed. The presented GA is able to deal with discrete- and continuous-valued design variables, as well as including a multispecies capability, and new genetic operators. In this manner, several laminated structures can be considered at the same time in the optimisation loop in order to find the least-weight design that fulfils certain structural requirements. The latter are calculated by means of an in-house finite element code based on the well-known Carrera Unified Formulation (CUF) [4], in which high-order structural models can be obtained and used to analyse the mechanical performance of multi-layered structures.

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