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A Two-Step Optimization Approach for Composite Structures Optimization Including Design Rules and Manufacturing Constraints

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ABSTRACT

In this paper, we describe a two-step solution procedure for the optimal sizing of aircraft composite structures including conventional plies oriented at 0°, 45°, 90° and -45°. The specific case of a fuselage section is considered. The structure is divided in several zones of possible different thickness and stacking sequences.

In the first step of the optimization procedure, the optimal thickness of the plies oriented at 0°, 90° and ±45° is obtained, assuming that the laminates are homogeneous in each zone. Here, buckling and post-buckling finite element analyses are conducted in the optimization loop, knowing that working with a geometric non-linear behavior allows providing more accurate safety margins and even allows decreasing the structural weight. This first step is solved with a gradient-based optimization algorithm working with continuous design variables [1].

Once the optimal thickness and percentages of plies at 0°, 90°, 45° and -45° are obtained in each zone, a specific backtracking algorithm developed in [2] is used. This algorithm allows determining the optimal stacking sequence in each zone of the structure, while satisfying the ply continuity constraints across the regions (i.e. the blending of the plies). This constraint must be satisfied in order to produce a composite part which can be manufactured. Moreover, the stacking sequence in each zone must satisfy specific design rules, e.g. there must be at most 4 successive (superposed) plies with the same angle, or the maximum gap between two adjacent (superposed) plies is 45°.

The methodology is demonstrated on an academic case and on a fuselage section made of a curved panel including several hat stiffeners defining zones of different material properties.

REFERENCES

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