37. <u>TOPOLOGY OPTIMIZATION OF COMPOSITE STRUCTURES</u> <u>WITH CONTINUOUS DESIGN VARIABLES WITH DESIGN RULES</u> <u>AND BLENDED LAMINATES</u>

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SUMMARY

The problem of identifying the optimal stacking sequence in laminates, has been investigated for a long time. In most practical applications, the candidate materials are restricted to -45°, 0°, 45° and 90° plies, which are the conventional orientations used in aeronautics. In order to propose solutions which are relevant for industrial applications, the optimal stacking sequences must satisfy specific design rules, such as the laminate must be balanced and symmetric, there must be no more than N_{max} successive plies with the same orientation in the laminate (N_{max} is often equal to 3 or 4), the transition between two plies must be at most of 45°, that is [0/90] and [45/-45] sequences are forbidden, and finally, minimum and maximum percentages of each possible orientation must exist. Blending of plies (i.e. the ply compatibility/continuity between the adjacent regions in a variable thickness and stiffness composite structure) is another requirement reflecting practical manufacturing considerations.

In this paper, an optimization procedure based on multi-phase topology optimization is developed to determine the optimal stacking sequence of laminates made up of conventional plies oriented at -45°, 0°, 45 and 90°, taking into account the design rules. The formulation relies on a parameterization in which the discrete optimization problem is replaced by a continuous approach with a penalty to exclude intermediate values of the design variables. In this approach, the material stiffness of each physical ply is expressed as a weighted sum over the stiffness of the candidate plies corresponding to -45°, 0°, 45 and 90° orientations. The methodology is demonstrated on an application, and it is illustrated how the different design rules can affect the solution.