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A MODIFIED TOPOLOGICAL SENSITIVITY ANALYSIS EXTENDED TO THE DESIGN OF COMPOSITE MULTIDIRECTIONAL LAMINATES STRUCTURES

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Abstract. The main purpose of this study is to analyze two main problems, namely the optimal design of multilayered composite laminates and the topological sensitivity analysis in anisotropic elastostatics. Regarding the composite design, minimal weight structures subjected to bending and Hoffmann failure criteria constraints are considered, where the design variables are the shape/topology of each ply and the stacking sequence. The application of topological sensitivity analysis is extended to obtain the optimal topology of composite laminated structures. From the topological Derivative mapping methodology, considering the total potential energy as an objective function, the optimal topology is obtained by gradual insertion of material in the considered domain. The Topological Derivative defines the shape of the new added plies, and the optimal layup is obtained by using an ant colony optimization algorithm. Numerical examples are presented to demonstrate the validity, functionality and applicability of the proposed methods.

Keywords: Topological Sensitivity Analysis; Ant Colony Optimization; Structural Design; Laminated Composite Plate.

1. INTRODUCTION

The increasingly intense use of optimization techniques applied to structural design problems, more specifically in the last three decades, has led to improvements in several aspects that encompass design procedure as a whole, such as:

i) development, due to the search for innovative solutions motivated by increasing technological competition, which translates to the use of new design methodologies in detriment of trial and error methodology;
ii) high structural efficiency, or the ratio of structure weight to supported load, which leads directly to the need to design increasingly lighter structural components;
iii) high rigidity, as even structural components conceived within the philosophy of having the lowest possible weight must respect design specifications related to limits of resistance and deformation, as well as dynamic behavior limits (frequencies);
iv) reduction in manufacturing costs, due to the ideal use of raw material and
v) to present the highest possible reliability, which leads to a very small number of failures within the operating regime foreseen in the pre-project phase, and in this way makes maintenance planning possible due to the greater component lifespan guarantee during the specified maintenance intervals.

Due to the structural design requirements currently established, mainly by the aeronautical and automotive industries, which were largely motivated by the imposition of new energy efficiency standards,

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