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A MEMETIC ALGORITHM FOR THE MULTI-OBJECTIVE OPTIMIZATION OF GEOMETRICALLY NONLINEAR COMPOSITE STRUCTURES

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ABSTRACT

A multi-objective optimization framework for the sizing and anisotropic topology of geometrically nonlinear beam-stiffened shell structures made of fiber-reinforced plastics is proposed. The objective functions for the proposed robust design approach are the minimization of mass and the strain energy's mean value, standard deviation and coefficient of variation. Their trade-offs are optimized while adhering to stress, displacement and buckling constraints. The design variables are the ply angles of the shell laminates, the ply widths of the beam laminates and the thicknesses and materials of all layers in the structure. The proposed Multi Objective Memetic Algorithm (MOMA) exploits the synergy between multiple Lamarckian and Baldwinian learning procedures, whose relative performance determines their selection for future offspring generation. Design space decomposition is achieved through the use of multiple sequentially-evolving subpopulations, while a virtual population with age-dominance dual nature updates the Pareto front and accelerates the global search. The concept of species serves as an abstraction of the search space discontinuities due to the presence of integer type design variables. The MOMA is validated through its application to two bi-objective and two tri-objective optimization problems.

Keywords: Memetic, multi-objective, hybrid composites, geometric nonlinearity.

INTRODUCTION

In an effort to reduce the costs associated with the manufacturing of FRP composite structures, considerable research has been devoted to the hybridization between expensive and higher stiffness materials and less expensive and lower stiffness materials. Memetic Algorithms have been shown to be an effective and efficient approach to this complex design problem (António, 2024).

RESULTS AND CONCLUSIONS

The MOMA was applied to the multi-objective optimization of a spherical composite structure composed of three shell laminates and three beam laminates, hinged along its perimeter and with a point load acting on its central node (Figure 1).

The MOMA was extended to be able to handle optimization problems with any number of objectives. Subsequently, the tri-objective optimization problem addressing the minimization of mass and the strain energy's mean value and standard deviation was studied. The results that were obtained illustrate its effectiveness in finding optimal solutions.

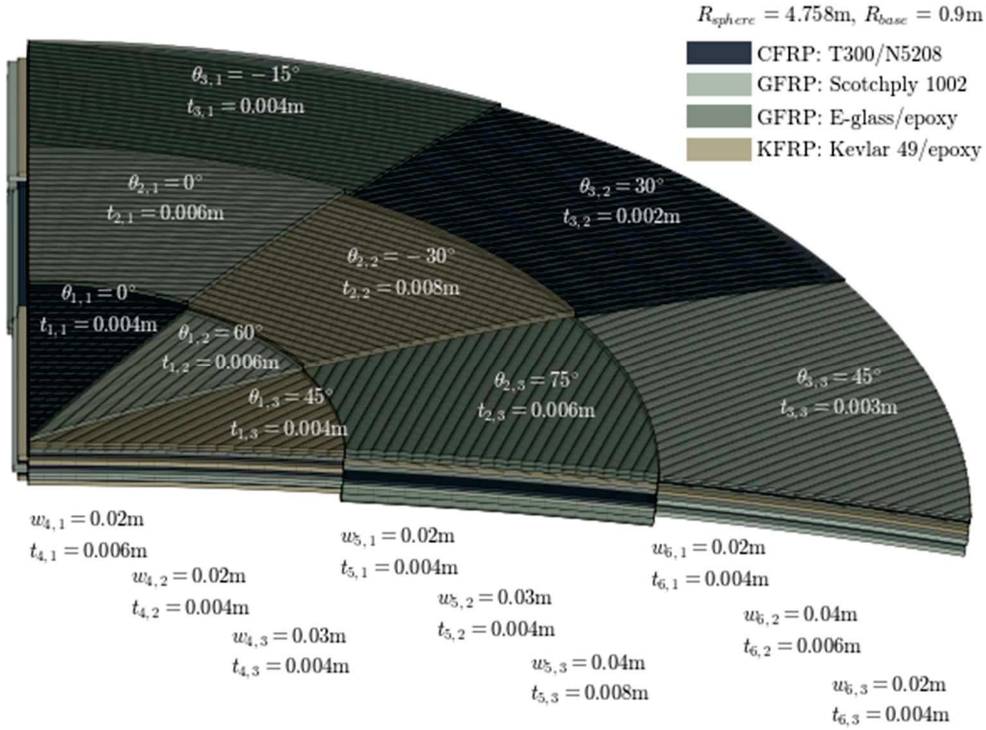

Fig. 1 - Beam-reinforced shallow shell structure for a given set of design variables.

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The study of species distribution on the Pareto front revealed a niching effect that validated the adopted domain decomposition that was based on the assumption that different material combinations offer specific trade-offs. Furthermore, this effect suggests that hybrid composites may unlock otherwise unattainable design solutions.

REFERENCES

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