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Stacking Sequence Optimization of Laminated Composite Grid Plates for Maximum Buckling Load Using Genetic Algorithm

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ABSTRACT

Grid structures are extensively used in many engineering structures as an orthotropic layer with at most in-plane anisotropy. In this study, the laminated grids structures are considered. These structures are composed of various numbers of thin composite grid layers. This concept yields to numerous laminated grid configurations with disparate coupling effects, which can be used to tailor the stiffness, compare to conventional grids. In the present study, four known grid patterns with equal weight and thickness constitute the laminated grids. The genetic algorithm (GA) is employed to optimize the stacking sequence and pattern composition of the laminated grid. The buckling load is taken as a fitness function and the pattern and orientation of the grid layer are considered as the design variables. The first-order shear deformation and classical laminated plate theories are considered along with Ritz method to obtain the elastic buckling loads. The optimization results are presented for various boundary conditions and aspect ratios. The results show, using the laminated grid considerably improves the axial buckling load of the plates. Moreover, the plate boundary conditions and aspect ratios play an imperative role in the optimum pattern and stacking sequence of the laminated grid plates.

Keyword: laminated grid, genetic algorithm, buckling, stacking sequence, optimization

1 INTRODUCTION

The grid structures are a reasonable choice in aerospace applications. They are also employed in vehicles and construction industries. Due to resistance to ambient conditions, low weight and production cost, the grids are generally made by composite materials. There are many known grid patterns in industries, such as, isogrid, orthogrid and anglegrid. Thus far, most investigations are concentrated on mechanical behavior prediction, fabrication and optimization of single layer grid structures.

Gürdal and Gendron [1] evaluated the structural efficiency of geodesically stiffened shells with various stiffener arrangements under compression, torsion and combined loads. Bedair [2] studied the effects of stiffener position on the stability of stiffened plates subjected to compression and in-plane bending. He presented a strategy to optimize the location of the stiffeners. Jaunky et al. [3] proposed an improved smeared stiffener theory for stiffened panels including skin-stiffener interaction effects. They showed; the result of the new method is more accurate than common smeared stiffener approach.

Adali et al. [4] presented optimal designs of symmetrically laminated composite plates subjected to a biaxial uncertain buckling load using anti-optimization. The ply angle is considered as the design variable. The optimal stacking sequences for both deterministic and robust designs are compared for a symmetric laminates with specific thickness subjected to uncertain in-plane loads. Buragohain et al. [5] analyzed buckling behavior of composite hexagonal grid shell using the smeared stiffener model. Totaro and Gürdal [6] searched for the minimum mass of anisogrid shells subjected to buckling and strength constraints. The effectiveness of the proposed optimization illustrated through preliminary design of a launch vehicle structure. Huang et al. [7] presented a new finite element modeling technique to