Frequency optimization of laminated composite plates

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Abstract
Laminated fibrous composite plates are finding a wide range of applications in structural design, especially for their light weight and high stiffness and strength. In this article, a genetic algorithm based optimum design method is presented to maximize fundamental frequency of laminated composite plates under any combination of the three classical edge conditions. The first natural frequencies of laminated composite plates were obtained from modal analysis of plates using the finite element method. Furthermore, first natural frequencies of the plate were defined as fitness function in Genetic Algorithm. Genetic Algorithm, which is one of the methods inspire from nature, can successfully optimize problems with discrete variables. The results from the proposed method show that the Genetic Algorithm predicted successfully the optimal layer sequences without yielding a local optimum.

Keywords: Modal analysis, Laminated plate, Genetic Algorithm, Optimization.

1. INTRODUCTION
Laminated composite materials are widely used in engineering applications, due to their high stiffness-to-weight and strength-to-weight ratios. Moreover, composite materials are particularly attractive because they can be designed to have specific properties in one direction without over designing other directions. Laminated plates are increasingly used in mechanical, civil and aerospace structures. In general, these structures are subjected to dynamic loading, and if they are not appropriately designed they may fail due to dynamic instability. Numerous studies have been done on vibration of isotropic and composite plates in recent years [1-5]. Many researchers have performed studies on frequency optimization of laminated plates. Bert [6] presented optimal laminate design for fundamental frequency maximization of thin simply supported composite plates. Duffy and Adali [7] determined optimal fiber orientations of antisymmetric, angle ply composite plates with the objective of maximizing their vibration characteristics. The design problems involved the maximization of the fundamental frequency and the frequency separations subject to a mass constraint. Kam and Chang [8] investigated optimal lamination arrangement for maximum buckling load and vibration frequency. Fukunagan et al. [9] examined optimal laminate configuration of symmetric laminated plates for maximum fundamental frequency using a mathematical programming method. Kam and Lai [10] studied lamination arrangements of thick laminated plates for optimal dynamic characteristics. They investigated the effects of length-to-thickness, aspect ratio and layer number on the optimum fiber orientations. Narita [11] presented Ritz-based layerwised optimization for symmetrical composite plates. His approach was based on physical observation that the outer layer has more stiffening effect than the inner layer in bending of laminated plates, thus the outer layer is more important in determining the maximum natural frequency of plates.

In this study, Genetic Algorithm approach has been used to maximize the natural frequency of plates with different aspect ratios and edges conditions. Therefore, the objective function in this problem is natural frequency of plates and design variables are considered as fiber angle of each layer, thickness and length/width ratio of the composite plates.