Maximum Stiffness and Minimum Weight Designs of Laminated Composite Shells Using Particle Swarm Optimization Algorithm

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ABSTRACT

The finite element constructed on the basis of the double curvature finite element method for degenerated 3-D shell element is developed for the design and analysis of composite shells (cylindrical shells and spherical shells). The 3-D shell element is applied to analyze the curved structure owing to its superior ability to 2-D analysis in simulating the geometrical protocol in reality. Moreover, the theoretical results are found to be superior to results from other studies and practical results, showing that the proposed hypothesis is workable. Utilizing the proposed finite element methods, the optimal lay-ups for the laminated composite shells with maximum stiffness and minimum weight, respectively, is designed via a constrained global optimization method. The theoretical and optimal results are compared with the experimental data. In the optimal design, the particle swarm optimization (PSO) algorithm is incorporated into the search probability formula for conducting two optimal design problems, namely, maximum stiffness design of laminated composite cylindrical shells and minimum weight design of laminated composite shells (cylindrical shells and spherical shells), with discrete design variables (fiber angle and thickness of layer groups) subject to unconstraint thickness and strength constraint, respectively. A number of examples of the design of symmetrically laminated composite shells with various loading, numbers of layers boundary condition, aspect ratio (B/A), radius-to-length ratio (R/A) and side-to-thickness ratio (A/H) are given to illustrate the applications of the present method. Besides, this research is used double genetic algorithm (DGA) and hybrid particle swarm optimization (HPSO) to compare with PSO and discuss the performance of search ability. Thus, the variety of algorithms applied the laminated composite shell structures can reach design goal and save cost.

Keywords : Composite ; Shells structures ; First-ply failure ; Minimum weight design ; Stiffness ; Optimal design method ; Particle Swarm Optimization

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