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OPTIMUM DESIGN OF LAMINATED COMPOSITES FOR MAXIMUM FATIGUE LIFE

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Summary: Composite structures especially used in the applications such as airplanes, wind turbine rotor blades, leisure boats, bridges are subjected to significant cyclic fatigue loads throughout their service life, which may lead to catastrophic failure. Therefore, fatigue is an important parameter that must be considered in calculations during design processes. Fatigue strength (fatigue life), thus structural performance of laminated composites, can significantly be increased through design optimization. However, there are no adequate studies in the literature on the optimum design of laminated composites under fatigue loading. Hence, in this study, optimum fibre orientation designs of laminated composites under various in-plane loading conditions are searched to obtain maximum fatigue strength. For this purpose, a fatigue assessment model termed as "Failure Tensor Polynomial in Fatigue (FTPF)" is used to predict the fatigue life of the laminates. A hybrid algorithm composed of genetic algorithm and generalized pattern search algorithm is used as the search algorithm in optimization. The first ply failure approach is implemented to the study using Hashin-Rotem failure criterion index in order to ensure the reliability of the designs. The validity and effectiveness of the model are investigated using experimental data available in the literature, and an experimental correlation is presented. A number of problems including different design cases are solved, and the best fibre angle orientations selected from a set of discrete angles by the algorithm and the corresponding failure indexes are proposed to discuss. A comparison study is also performed with selected design cases to demonstrate potential advantages of using non-conventional fibre angles in design. In addition, the performance of the hybrid algorithm is shown for some design cases by comparing to single performances of genetic and generalized pattern search algorithms.