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Simultaneous Optimization of Stiffeners Distribution and Sizing using Two-Level Approximations and Genetic Algorithm

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Abstract

Stiffened shell is widely used in aerospace structures. We proposed a new method to optimize the topological distribution and cross-sectional dimensions of the stiffeners. Based on a ground distribution of the stiffeners, we establish a uniform optimization model including continuous size variables (cross-sectional dimensions of stiffeners and thicknesses of shell) and discrete variables (0/1 variables that represent the existence of each stiffener). Minimum structural weight is taken as the objective, and natural frequencies and displacement could be taken as constraints. Since mixed-variables are involved in the optimization model, a hierarchic optimization method is introduced. First of all, the discrete variables are optimized through the GA to obtain optimal distribution of the stiffeners. When calculating the fitness of each member in the population of GA, a first-level approximate problem is constructed using the branched multipoint approximate (BMA) function to obtain constraint value and objective value. To solve the first-level approximate problem, a Taylor expansion function is used to construct the second-level approximate problem, which can be solved by the dual method to obtain the optimal solution of continuous size variables. Main attention is paid to applying this optimization method to practical engineering structures with good efficiency at a low computational cost. The method is first applied to a rectangle plate with rectangular section stiffeners to test its feasibility compared with known methods. Then the optimal result of an engineering structure(a stiffened conical shell) demonstrates the practicability and efficiency of the proposed method.