A Coupled Stiffened Skin-Rib Fully Gradient Based Optimization Approach for a Wing Box Made of Blended Composite Materials

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Abstract : A method is introduced for the coupled skin-rib optimization of a wing box where mass minimization is the objective and local buckling is the constraint. The structure is made of composite materials where continuity of plies in multiple adjacent panels (blending) has to be satisfied. Blending guarantees the manufacturability of the structure; however, it is a highly challenging constraint to treat and has been under debate in recent research in the same area. To fulfill design guidelines with respect to symmetry, balance, contiguity, disorientation and percentage rule of the layup, a reference for the stacking sequences (stacking sequence table or SST) is generated first. Then, an innovative fully gradient-based optimization approach in relation to a specific SST is introduced to obtain the optimum thickness distribution all over the structure while blending is fulfilled. The proposed optimization approach aims to turn the discrete optimization problem associated with the integer number of plies into a continuous one. As a result of a wing box deflection, a rib is subjected to load values which vary nonlinearly with the amount of deflection. The bending stiffness of a skin affects the wing box deflection and thus affects the load applied to a rib. This indicates the necessity of a coupled skin-rib optimization approach for a more realistic optimized design. The proposed method is examined with the optimization of the layup of a composite stiffened skin and rib of a wing torsion box subjected to in-plane normal and shear loads. Results show that the method can successfully prescribe a valid design with a significantly cheap computation cost.

Keywords : blending, buckling optimization, composite panels, wing torsion box
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