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Control the thermal response of thin-walled structures using the robust design method

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ABSTRACT

Thermal responses, such as the thermal deflection and thermal moments, are mainly determined by temperature gradient on the cross-section of thin-walled structures. These thermal responses could be controlled by optimally designing material parameters. However, material parameters always have some uncertainties in practice, especially for composites. These uncertainties will introduce some unexpected variations on structural performances. To minimize these variations, a robust design method [1, 2] is developed in this paper. This method is formulated as a multi-objective optimization, which tries to minimize the mean and variance of temperature gradient simultaneously. A stochastic Finite Element (FE) program, based on the second-order perturbation, is developed to obtain the approximation of the mean value and the variance of the temperature gradient [3]. This stochastic FE code utilizes a kind of Fourier temperature beam element [4], which has the degrees-of-freedom of average and perturbation temperatures on each node, so that the temperature gradient can be calculated efficiently. The optimization problem is solved by Gauss-Newton method. All sensitivities needed are calculated through the analytical formulation of the derivative of temperature statistics with respect to design variables [5, 6]. Finally, the validity of this method is illustrated by comparing the results with ones from Monte Carlo simulations.

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