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Aerothermoelastic Structural Topology Optimisation for a Hypersonic Transport Aircraft Wing

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Abstract

Aerothermoelasticity plays a vital role in the design of hypersonic aircraft as a strong coupling exists between the aerothermodynamic loads and the structural response. Fluid-thermal-structural interactions are one of the multidisciplinary problems that must be solved for the design of hypersonic aircraft. Existing optimisation algorithms lack the capability to include these aerothermodynamic coupling effects. This article presents a novel bi-directional evolutionary structural topology optimisation algorithm that includes aerothermoelastic coupling effects. The time-varying temperature distribution is applied through an original formulation, solving for equilibrium of convective, radiative and through thickness conduction at each time step, with a time-marching unsteady conduction solution for time integration. The thermal solution is coupled with a high order aerodynamic solver and the structural finite element model. The results presented in this article show that the coupling between the thermal, structural and aerodynamic forces drive the optimisation of the design and must be taken into consideration to achieve a feasible working structure for the required environment.

Keywords: Hypersonic; Aerothermoelastic; Evolutionary; Aircraft.