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PROCEEDINGS

Aerothermoelasticity Research of Hypersonic TPS Panel using Kriging Surrogate Reduced Order Model

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ABSTRACT

Hypersonic aircraft face complex aerodynamic forces and severe aerothermal issues. While aerodynamic and aerothermal empirical solutions exhibit high computational efficiency, they lack precision. Numerical approaches equipped with accuracy but come with high computational costs. To address the contradiction between precision and efficiency, some research on hypersonic unsteady aerodynamic and aerothermal Reduced Order Models (ROMs) was conducted in this study, using Kriging surrogate method.

Meanwhile, hypersonic aircraft typically feature numerous thin-wall structures. The strong coupling of aerodynamic, aerothermal, and elasticity will inevitably lead to aerothermoelastic effects. This study centered on the Thermal Protection System (TPS) panel at the inlet cowl of the typical hypersonic vehicle X-43. The finite difference method (FDM) is used to solve the heat conduction partial differential equations (PDE), obtaining the structural temperature field under the influence of aerothermal heat flow. The aerothermoelastic response was solved by finite element method (FEM) to take the influence of structural temperature loads into consideration. Considering computational efficiency, aerothermal-aeroelasticity one-way coupling strategy is adopted.

Using aerodynamic and aerothermal ROMs, the aerothermoelasticity of the TPS panel was investigated, and computational efficiency was significantly improved by comparison. Numerous nonlinear dynamic responses, including thermal buckling, limit cycles, periodic responses, and chaos, were observed.

KEYWORDS

Hypersonic; Aeroelasticity; Aerothermoelasticity; Reduced Order Model (ROM); Kriging surrogate model

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