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Reduced Order Model based on SPOD for Aerothermoelastic Analysis of a Hypersonic Panel

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ABSTRACT

This study has established a reduced order model (ROM) based on spectral proper orthogonal decomposition (SPOD) method in order to proceed an aerothermoelastic response analysis of a hypersonic panel. The two-way coupling between aerothermal and aeroelastic systems is applied [1]. Three aspects of POD-ROM are investigated: 1) the selection of snapshots for POD modes; 2) the comparison between classical POD [2] and SPOD [3]; 3) how to find global POD modes in a parameter space of flight altitude and Mach number. The snapshots are sampled from aerothermoelastic response data via the classical Galerkin method. The numerical results show that the dynamic response of the panel in time history is stable flat first, dynamically stable buckling, and subsequently flutter occurs with transient chaos and then limit cycle oscillation (LCO). Moreover, we find that: 1) the selection of the entire time response as the snapshots for production of POD modes reveals that the long-term buckling and LCO response will interfere the resulting POD modes. Therefore, taking the transient chaotic response as snapshots is a better choice; 2) compared with the classical POD method, the proposed SPOD method for the present aerothermoelastic system improves the accuracy and efficiency obviously; 3) the global POD modes here are essentially the natural modes of the aerothermoelastic panel and thus are related to the temperature of panel. This is of great significance to further understand the physical mechanism of the present aerothermoelastic system and develop fast calculation methods.

KEYWORDS

Hypersonic; Aerothermoelasticity; two-way coupling; reduced order model; spectral proper orthogonal decomposition

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References

1. Culler A. J., McNamara J. J. (2010). Studies on fluid-thermal-structural coupling for aerothermoelasticity in hypersonic flow. *AIAA Journal, 48(8),* 1721–1738.
2. Xie D., Xu M., Dowell E. H. (2014). Proper orthogonal decomposition reduced-order model for nonlinear aeroelastic oscillations. *AIAA Journal, 52(2),* 229–241.
3. Towne A., Schmidt O. T., Colonius. T. (2018). Spectral proper orthogonal decomposition and its relationship to dynamic mode decomposition and resolvent analysis. *Journal of Fluid Mechanics, 847,* 821–867.