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SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
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ON A PARAMETRIC ANALYSIS OF THE AEROTHERMODYNAMICS FLUID-STRUCTURE INTERACTION

Abstract

An analytical model of the aerothermodynamics of fluid-structure interaction through an ablative wall is developed, involving: (i) the solution of the Navier-Stokes equations in the fluid; (ii) the solution of the equations of thermoelasticity in the solid wall; (iii) the matching of the two solutions across the fluid-wall interface by continuity of normal and tangential stresses and jump of the heat flux equal to the heat of ablation. These three matching conditions determine the three constants of integration, besides the boundary conditions: (i) in the free stream far above the wall, the fluid velocity and temperature are given; (ii) in the backing material below the wall the temperature is given and displacement is assumed to be zero. In order to arrive at a simple analytical solution the simplest geometry is chosen: two-dimensional, with a flat fluid-wall interface, and all quantities in the fluid and structure depending only on distance from the wall. Extensions to unsteady and three-dimensional cases would be more complex. The present theory specifies: (i) the velocity, pressure and density in the fluid; (ii) the displacement vector, and strain and stress tensors in the structure; (iii) the temperature and heat flux in the fluid and structure, including discontinuities across the fluid-wall interface. The model is applied to examples of (a) hypersonic flight and (b) atmospheric re-entry.