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SURFACE HEAT FLUX ESTIMATION AND NEW CALIBRATION METHODS FOR GROUND-BASED TESTING IN HYPERSONIC ENVIRONMENTS

Abstract

Hypersonic flight requires the accurate quantification of heat flux in severely hostile environments. Both thermal protection systems (TPS's) and structurally integrated thermal protection systems (SITPS's) are required for maintaining vehicle and propulsion integrity at significantly elevated temperatures and heat fluxes. Hypersonic combustor effectiveness can also be evaluated by accurate estimation of heat losses from the flow to the surrounding structure. In these applications, accurate surface predictions are required for both temperature and heat flux. In-depth substrate measurements require the use of analytic tools for extracting stable and accurate surface predictions. At the present time, the UTK research group is developing new methodologies and guidelines for instrumentation and controlled laboratory testing applicable for use in ground or flight tests. The guidelines provide analytic tools and procedures for determination of sensor time constants, material properties (if needed), probe positioning, and prediction and verification of the surface temperature and heat flux. A combined experimental and analytical approach is under development based on several recent theoretical observations and a newly developed and patented heating rate sensor (K/s). Additionally, locating the onset of transition in hypersonic flows may be determined though embedded (in-depth) rate based sensor technology.

This paper describes several new developments useful to the aerospace community. In particular, the paper discusses:

1) relationships for estimating the local heat transfer in anisotropic materials in two-dimensional geometries using in-depth sensors; 2) relationships for estimating the total surface heat transfer in two-dimensional geometries from in-depth sensors; 3) new calibration methods for estimating in-situ thermocouple time constants and embedded probe locations in one-dimensional geometries; 4) new in-situ methods using two in-depth sensors for estimating time constants and thermophysical properties without requiring knowledge of the surface heating source in one-dimensional geometries; and, 5) new rate-based (patented) sensor technology that assists in both the estimating surface heat flux from in-depth measurements; and, the location of transition in hypersonic flows from in-depth measurements.