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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Advanced Materials and Structures for High Temperature Applications (4)

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UNIVERSITY OF KENTUCKY PLASMA DIAGNOSTIC FACILITIES FOR THE INVESTIGATION OF GAS-SURFACE INTERACTIONS

Abstract

The development of reliable thermal protection systems for atmospheric entries requires extensive material testing in ground test facilities under conditions relevant for high speed reentry such as the NASA Ames arc-jets. However, even these high power facilities are not capable of reproducing real-flight conditions. Instead, an extrapolation of the ground test data to the atmospheric entry is necessary, which is achieved through aerothermochemistry simulation codes. These simulations require a thorough understanding of the conditions during ground testing and their relation to flight which comprises a precise characterization of the plasma flows involved. Unfortunately, the operation of these facilities is usually very expensive and on a tight testing schedule, which makes them not suitable for basic research projects, parametric investigations of individual processes, and proof-of-concept studies. The development of diagnostic methods as well as the generation of validation data for simulation codes, e.g. for the material response of ablative heat shield materials, is accomplished far easier in smaller, more flexible, and less expensive facilities which are not on a similarly constricted schedule. For these purposes, two low power plasma facilities for the generation of high enthalpy plasma flows are under development at the Department of Mechanical Engineering of the University of Kentucky. The plasma is generated by a 10 kW radio frequency generator operated at 13.56 MHz for operation at low pressures and a 3 kW micro wave generator at 2.5 GHz, which can be operated up to atmospheric pressures. The plasmas are not anticipated to reproduce re-entry conditions but to provide a highly controlled environment which can be rebuilt by simulation codes. The electrode-less plasma generation in both facilities enables operation even with highly reactive gases, e.g. pure oxygen or CO2. The facilities will be used for optical diagnostics of the plasma itself and gas-surface interactions with material samples. Of particular interest are remote recession measurement techniques using seed materials inside an ablative heat shield material. The time resolved spectral plasma emission provides information of the surface recession past the seeding material. Different emission spectroscopy set-ups are in development, which will be applied to the plasma flows in these facilities, but also to larger facilities at NASA. The paper will give an overview of the plasma diagnostic facilities at the University of Kentucky, the intended goals for the near future, and present some first data.