Paper ID: 46403
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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Advanced Materials and Structures for High Temperature Applications (4)

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OXIDATION AND HETEROGENEOUS CATALYSIS ON TITANIUM TI-6AL-4V IN HIGH-ENTHALPY FLOWS

Abstract

Recent experimental investigations using Plasma Wind Tunnels (PWT) at the Institute of Space Systems (IRS) have demonstrated that grade 5 titanium Ti-6Al-4V shows little tendency to demise in Low Earth Orbit (LEO) entry conditions. While this is highly problematic with regards to the safe disposal of spacecraft using components made of Ti-6Al-4V through destructive re-entry (e.g. pressure vessels), conversely a potential suitability of this alloy for TPS applications can be noted. In addition to exhibiting superior thermophysical properties when compared to most other metals in this context, thermochemical interactions with high-enthalpy oxidising air flows generally appear to increase the survivability of Ti-6Al-4V during re-entry, with e.g. the surface emissivity and thus its radiative heat dissipation capability increasing dramatically through oxidation. Additional heat-flux-mitigating effects associated with the material's beta phase transition have been observed. These effects are reported in the context of the experimental investigations and discussed. The current work further presents experimental results obtained on the investigation of the surface catalysis on grade 5 titanium Ti-6Al-4V under pure oxygen and nitrogen flows of pre-oxidised and pristine surfaces. This enables the generation of complex catalysis models for a wide range of surface temperatures and pressure regimes that can later be implemented in simulation tools for high-fidelity destructive re-entry predictions or for the design of mission-specific TPS. The methodology combines an experimental investigation in PWK3, a PWT driven by an Inductively heated Plasma Generator (IPG), with a numerical computation using the in-house Navier-Stokes solver for non-equilibrium flows called URANUS for the reconstruction of the boundary layer. Unlike other metallic materials, grade 5 titanium Ti-6Al-4V exhibits low catalysis within the examined flow regimes, attesting to its low propensity towards succumbing to aerothermal demise as well as its potential for TPS applications.