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Author: Mr. Xun Wang
CALT,CASC, China, xunxun__19891121@126.com

Mr. Zhanwei Cao
CALT,CASC, China, 745990656@qq.com
Mrs. Na Jin
CALT,CASC, China, 214849129@qq.com
Mr. Xuan Chen
Science and Technology on Space Physics Laboratory, China, rocketman001cx@163.com
Dr. Jin Yin
China Academy of Launch Vehicle Technology (CALT), China, yinjin0709@126.com

A STUDY ON IMPACTS OF HIGH ENTHALPY EFFECT IN DESIGNING ARC JET WIND TUNNEL EXPERIMENTS FOR HIGH TEMPERATURE THERMAL PROTECTION MATERIAL

Abstract

Thermal Protection System (TPS) is of crucial significance in designing aerospace systems for Mars entry, Reusable Launch Vehicle, reentry modules etc. Due to the extremely high temperature behind shock wave and within viscous boundary layer during atmospheric reentry flight, various advanced TPS materials are invented and utilized to protect electronic components on board and weight-bearing structures from being damaged. Prior to deployment of TPS system, systematic ground tests are required to validate the effectiveness of TPS system under flight environment.The arc jet wind tunnel experiment is the best approach to exert heat load on TPS material. Due to the high enthalpy property of arc jet flow, the gas in the test section of wind tunnel is usually dissociated, and the combination effect of atoms causes a heat discrepancy on surfaces of different catalytic qualities. Usually,the heat sensor made from copper is fully catalytic and its measured heat is an indicator of the experiment. Meanwhile, TPS material with various catalytic combination coefficients can not fully experience that amount of heat. Therefore, the experiment is sometimes under-examined. To investigate the difference between sensor-measured heat flux and heat flux experienced by TPS material, a series of numerical simulations are performed on the flat plate in arc jet wind tunnel. A validated in-house code based on Navies-Strokes equations is used with consideration of thermal and chemical inequilibrium, which is suitable for high enthalpy flow in wind tunnel. Various boundary conditions and total flow properties are set to quantatively assess the effectiveness of ground tests for different kinds of TPS material. Furthermore, calculated gas composition and flow properties in both flight and ground test conditions are analysed to interprete the impact of total enthalpy and catalytic effects on aeroheating difference. Finally, suggestions for designing arc jet tests for SiC TPS are proposed based on the analysis.