AVCOAT DENSITY CHARACTERIZATION FOR ORION MULTI-PURPOSE CREW VEHICLE (MPCV)

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The Orion Multi-Purpose Crew Vehicle (MPCV) will transport four crew members to and from lunar-class orbital destinations. The first orbital Exploration Flight Test (EFT-1) is scheduled for December 2014 and will provide valuable data on several systems, including the heat shield[1]. The heat shield material is AVCOAT^{TM}, a mid-density ablator containing a fiberglass-phenolic honeycomb structure filled with an ablative epoxy novolac resin[2]. Post-flight characterization of the EFT-1 heat shield will be conducted in order to study the material response and support reduction of the flight instrumentation data. The material characterization work involves making measurements of the density profile through the thickness of the AVCOAT. Results from the post-flight characterization of the EFT-1 heat shield can lead to further development of more accurate TPS material response models in order to better design heat shields more efficiently for future exploratative space missions.

The objective behind the present work is to develop a density characterization process using material from post-test AVCOAT arc jet coupons. Techniques for extracting material cores, progressively machining the cores, and determining a density profile will be given. A discussion of how the density characterization process can be applied to the flight vehicle will also be provided. The EFT-1 flight heat shield is also instrumented with thirty-four sensor plugs, nineteen of which contain a Hollow aErothermal Ablation and Temperature (HEAT) sensor to track the transient char front of the AVCOAT during atmospheric entry[3]. A secondary objective of the present work is to compare the char depth determined from HEAT sensor output to the char profile determined from the density measurements.

As a means to (1) test and certify the material response of AVCOAT, (2) certify the thermal plug sensor instrumentation for flight (including the HEAT) and (3) demonstrate the instrumentation does not compromise the AVCOAT material performance at margined flight conditions, several arc jet tests have been conducted.

AVCOAT coupons were tested at the NASA Ames Research Center Arc Jet Complex and at the NASA Johnson Space Center ARMSEFF facility. The Arc Jet facilities were used to simulate reentry atmospheric heating environments on ground test articles in stagnation and shear flow configurations. The arc jet tests helped to study the AVCOAT material response under steady-state and time-varying conditions which were based on predicted flight environments. Figure 1 shows an example of a pre- and post-test arc jet coupon used for material density characterization.

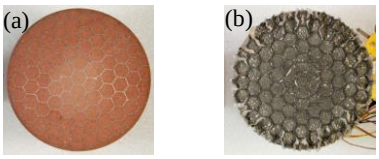

Figure 1: (a) Pre- and (b) post-test arc jet coupons

Plots of AVCOAT material density vs depth from the surface will be shown as a function of test condition. Additionally, data from arc jet coupons instrumented with a HEAT sensor will also be shown for comparison purposes.

References:

[1] Daum, J. and Gary, R. AIAA Guidance, Navigation, and Control (GNC) Conference. August 19 - 22, 2013, Boston, MA. AIAA 2013-4877.

[2] Alunni, A. I.; Olson, M.W.; Gokcen, Tahir; Skokova, Kristina. 42nd AIAA Thermophysics Conference. June 27 – 30, 2011, Honolulu, Hawaii. AIAA 2011-3776.

[3] Oishi, T., Martinez, E., and Santos, J. 46th AIAA Aerospace Sciences Meeting and Exhibit. January, 2008, Reno, NV. AIAA 2008-1219.