AEROTHERMAL SESSION TOPICS

Aerothermal Paper Session #1 (Tuesday 7:30AM to 11:30 AM)

ID	Title	Lead Author
TFAWS2012-AE-01	A Simplified Plume and Aerothermal Heating Analysis for LDSD	Mike Pauken
TFAWS2012-AE-02	Numerical Modeling of Solid Rocket Motor Plumes	Manish Mehta
TFAWS2012-AE-03	A Plume Impingement Test for Code Validation	Jason Mishtawy
TFAWS2012-AE-04	Space Launch System Base Convective Heating Test: Preliminary Design Analyses and Test Improvements	Manish Mehta
TFAWS2012-AE-05	Interfacial Design of Composite Ablative Materials	Tapan Desai
TFAWS2012-AE-06	Space Shuttle Boundary Layer Transition Flight Experiment Overview	Karen Berger

TFAWS2012-AE-01

Simplified Plume and Aerothermal Heating Analysis for LDSD

Mike Pauken, Jet Propulsion Laboratory, California Institute of Technology

ABSTRACT

Placeholder for abstract (it is written but waiting on export control approval).

TFAWS2012-AE-02

NUMERICAL MODELING OF SOLID ROCKET MOTOR PLUMES

Manish Mehta, NASA Marshall Space Flight Center
Brandon Williams, Computational Fluid Dynamics Research Corporation (CFDRC)
Gabriel C. Putnam, All-Points-Logistic (APL)
Sheldon D. Smith, Jacobs ESTS Group - Plumetech

ABSTRACT

In support of prediction of the launch pad plume deflector environments during solid rocket booster derived NASA STS (Space Shuttle) vehicle ascent, the solid rocket motor plumes have been successfully modeled and analyzed with the Loci-CHEM Navier-Stokes computational fluid dynamics (CFD) code - Lagrangian Model at a steady-state approximation. Three main areas have been addressed in this paper: (1) sensitivity study of the Loci-CHEM-Lagrangian model with various other Loci-CHEM modeling approaches; (2) in-depth analysis of the aerophysics associated with solid rocket motor plumes; (3) comparison studies between the CFD numerical simulations and flight data and an independent engineering code, Reacting and Multi-Phase Program (RAMP2). The reusable solid rocket motor plumes are a multi-phase flow which contains both plume gases and ~16% solid aluminum oxide particles by mass. This contribution of solid particles is shown to have a large impact on the aerophysics of the plume gases and the environments of the launch pad plume deflector. The Loci-CHEM–Lagrangian model shows the best overall agreement with plume deflector flight data and the RAMP2 engineering code. These modeling approaches are being implemented to conduct higher fidelity numerical simulations for the Space Launch System ascent and launch pad environments.

TFAWS2012-AE-03

A PLUME IMPINGEMENT TEST FOR CODE VALIDATION

Jason Mishtawy, NASA Marshall Space Flight Center

ABSTRACT

A 20 second ground test firing of the Solid Rocket Test Motor (SRTMV) was conducted at NASA Marshall Space Flight Center (MSFC) on March 15 2012. This test, designated as N2, was conducted to test nozzle materials and investigate the influence of small flaws in the propellant grain. A piggy-back test was included placing a highly instrumented 36” x 32” x 1” stainless steel panel 4’ downstream from the nozzle exit, ~17” outboard from the centerline and inclined 6° to the plume thrust vector to measure direct plume impingement environments. In addition two material samples, P-50 sheet cork and Vamac, were integrated into the test panel to measure material recession throughout the test. High quality test data were recorded for 96 static pressure measurements, 6 unsteady pressure measurements, 46 surface temperature measurements, 12 surface total heat flux measurements, 4 radiative heat flux measurements, and 9 accelerometer measurements. Additionally 13 backside wall temperatures, 3 backside ambient temperatures and 12 TPS sample bond-line temperatures were also recorded. Data from this test compares various heat transfer measurement techniques and instrumentation types and includes a new instrument that simultaneously measures surface temperature and material temperature at two depths below the surface called a tri-coaxial thermocouple. Initial findings indicate agreement between various instrumentation types and seemingly physical trends throughout the test firing. Data gathered from this test is suited for code validation.

TFAWS2012-AE-04

SPACE LAUNCH SYSTEM BASE CONVECTIVE HEATING TEST: PRELIMINARY DESIGN ANALYSES AND TEST IMPROVEMENTS

Manish Mehta, NASA Marshall Space Flight Center
Mark Seaford, NASA Marshall Space Flight Center
Brandon L. Mobley, Jacobs – Qualis
Robert D. Kirchner, Jacobs – Qualis
Carl D. Engel, Jacobs – Qualis

ABSTRACT

The NASA Marshall Space Flight Center Aerosciences Branch (EV33) is responsible for developing ascent plume induced thermal design environments for the Space Launch System (SLS) 10001 vehicle. Due to the complex nature of the rocket plume-induced flows within the launch vehicle base during ascent, testing is required to mitigate unknown risks. A sub-scale SLS base heating test is being designed to verify our semi-empirical and CFD models and to more accurately predict base flight environments. This sub-scale hot-fire test will be conducted at the Calspan-University of Buffalo Research Center's (CUBRC) LENS II facility to simulate altitudes from sea-level to 200 kft.

Five areas of analyses in support of these tests are presented in this paper: (1) determination and prediction of the target design altitude points which feed into the test matrix, (2) core-stage and booster element nozzle material and scale sensitivity study, (3) core-stage and booster element inner-nozzle boundary layer specific enthalpy flow analysis, (4) dynamic similarity analysis and (5) core-stage gas propellant feed system design. The preliminary analyses recommend various innovative testing methodologies to improve data fidelity and feed into the test facility and instrumentation optimization.

TFAWS2012-AE-05

INTERFACIAL DESIGN OF COMPOSITE ABLATIVE MATERIALS

Dr. Tapan G. Desai, Advanced Cooling Technologies, Inc.
Dr. John Lawson, NASA Ames Research Center
Prof. Pawel Keblinski, Rensselaer Polytechnic Institute

ABSTRACT

Ablative materials are thermal insulators used in hypersonic space vehicles. They are typically carbon reinforced composites with a phenolic resin matrix, which absorb heat in part through endothermic pyrolysis of the matrix. The char produced as a result of these reactive processes yields a thermally insulating and protective layer at the material surface. Optimization of the thermal protection system requires accurate prediction of the (currently ambiguous) pyrolysis process and the evolution of char morphology. A materials development software package is currently being developed that will consist of the following two modules: (i) an experimentally validated, atomistic-level simulation engine capable of predicting the role of interfacial structure on the resin-to-carbon process and (ii) atomistically-informed continuum-level thermo-mechanical performance analyzer for composite ablative materials subjected to transient pyrolytic conditions. The presentation will include a brief summary of this package and detailed results on reactive molecular dynamics simulations performed to study the initial stage of pyrolysis of phenolic polymers with carbon nanotube and carbon fiber. Furthermore, the effect of degree of crosslinking on pyrolysis and graphitic precursor formation will be presented.

TFAWS2012-AE-06

SPACE SHUTTLE BOUNDARY LAYER TRANSITION FLIGHT EXPERIMENT OVERVIEW

Karen T. Berger, NASA Langley Research Center
Brian P. Anderson, NASA Johnson Space Center
Charles H. Campbell, NASA Johnson Space Center
Michael T. Garske, NASA Johnson Space Center
Gerald R. Kinder, The Boeing Company
Ann Micklos, United Space Alliance

ABSTRACT

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