ARA Ablatives Laboratory

National Aeronautics and Space Administration

EDL HEATSHIELD EXPERIMENTS WITH DUAL-LAYER ABLATORS, ADVANCED MATERIALS AND VARIABLE HONEYCOMBS

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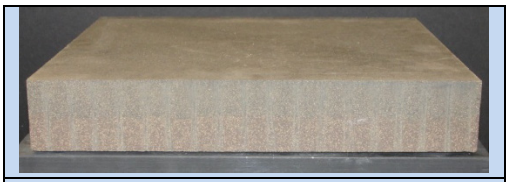
1) DUAL-LAYER ABLATORS

Silicone Ablators – 20 over 14 lb/ft^3 (S20/14)



Phenolic Ablators – 28 over 15 lb/ft^3 (P28/15)

ABSTRACT

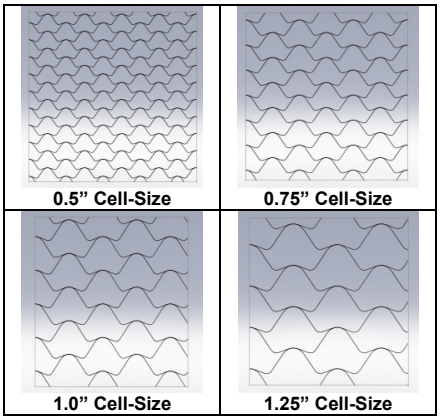
Today's challenge is to make ablative heatshield systems lighter and more efficient for thermal protection. The Ablatives Lab is conducting a three year project to explore enhancements of current ablator systems. This poster presents project design and objectives, test methods, preliminary findings, and continuing work. The project is focused on three elements:

1) Fabricate and test dual-layer (D-L) ablator systems with a higher-density, more robust top layer over a lower-density, more insulative sublayer of the same chemistry;

2) Investigate new resin systems as well as new ablator constituents to replace less-durable fillers currently in use; and

3) Produce, test and evaluate honeycombs (H/C) with a wide range of cell-size to better understand the dependence of ablator performance on reinforcement configurations.

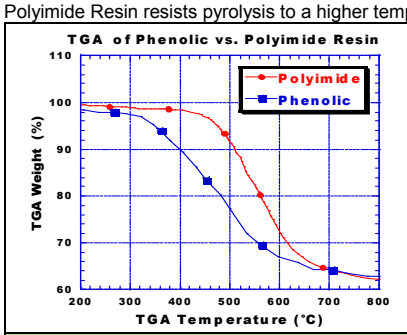
3) VARIOUS CELL-SIZE HONEYCOMBS



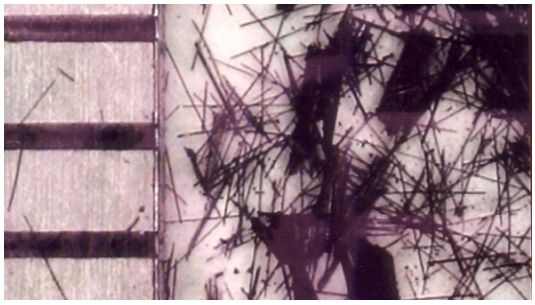
0.5" Cell-Size | 0.75" Cell-Size | 1.0" Cell-Size | 1.25" Cell-Size

2) NEW RESIN SYSTEMS AND ABLATOR CONSTITUENTS

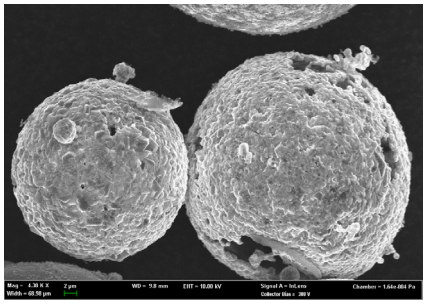
Polyimide Resin resists pyrolysis to a higher temperature than Phenolic Resin; Silicon-Carbide (SiC) microballoon and fiber constituents are stable up to ~2700°C



Polyimide RP-46 High-Temperature Resin from Unitech Corp.



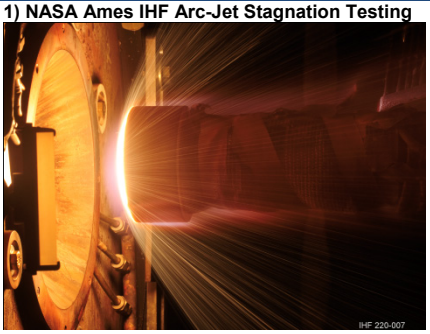
Nicalon SiC Chopped Fiber (1 mm) from Nippon Carbon Co.



SiC Coated Carbon Microballoons from Trelleborg Corp.

THREE DIFFERENT TESTS TO EVALUATE PERFORMANCE

1) NASA Ames IHF Arc-Jet Stagnation Testing



Test Purposes: relative surface recession and mass loss, relative bondline temp measurements to evaluate insulation performance

2) NASA Ames IHF Arc-Jet Aeroshear Testing

Test Purposes: relative surface erosion and mass loss in a shear environment, relative bondline temp measurements to evaluate insulation performance

3) Sandia Solar Tower (ST) Radiation Testing

Test Purposes: relative insulation performance, relative radiation penetration, spallation resistance, dual-layer thermal efficiency

KEY PRELIMINARY FINDINGS AND CONTINUING WORK

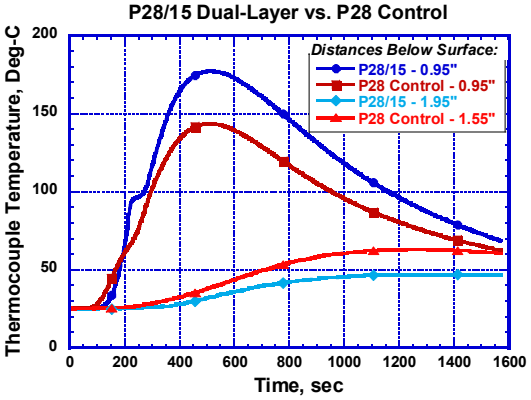
We are only partially through the full scope of this project (in June 2011), thus about half of the sample sets have been tested to date. Presented below are some initial observations from the first round of completed testing. A second round of shear, stagnation, and radiation testing is planned before project end.

1) DUAL-LAYER ABLATORS: Tested only at ST Facility. Phenolic and silicone D-L sample thermocouples (T/Cs) in bondline (1.95" below surface) show lower temps than controls. Bondlines for controls were located at a depth with same area weight as D-L samples (1.55" below surface for P28 control & 1.64" below surface for S20 control). D-L phenolic and silicone T/Cs between layers (0.95" below surface) show higher temps vs. controls (at same 0.95" depth). No separation of layers or spallation observed. Samples need to be sectioned to evaluate radiation penetration.

2) VARIOUS CELL-SIZE HONEYCOMBS: ST tests show a trend in bondline temps for various cell-size H/C. Smaller cell-size H/C showed slightly higher T/C temps than large cell-size H/C. These trends were not as distinguishable in shear or stagnation testing. Shear tests show less erosion in areas where H/C ribbons are closer together. More samples will be tested to generate a larger data set.

3) NEW RESIN SYSTEMS AND ABLATOR CONSTITUENTS: SEM photos show separation of SiC coatings from carbon microballoons on stagnation samples causing higher T/C temps and more recession and mass loss from testing compared to control. Trelleborg has developed and delivered fully SiC microballoons (with no coatings) for our next round of ablator sample testing. Samples containing SiC fibers and samples with polyimide resin showed lower temps & improved insulation over their control. More testing at longer exposure times is planned to thermally stress samples to a greater degree.

Comparison of Thermocouple Responses P28/15 Dual-Layer vs. P28 Control



Solar Tower Test - 100 W/cm^2 for 160 sec