Mechanical Testing of Carbon Based Woven Thermal Protection Materials

John Pham1, Parul Agrawal2, James O. Arnold3, Keith Peterson2 and Ethiraj Venkatapathy4
1USRA, NASA Ames Research Center
2ERC Inc., NASA Ames Research Center
3NASA Ames Research Center

Objective
Assessment of the structural integrity of 3-D woven carbon cloths that have undergone heating similar to Venus atmospheric entry conditions.

Background
- Planetary Science Decadal Survey expresses interest in Venus
- NASA proposes Venus Intrepid Tessera Lander (VITAL) mission
- Implement game changing technology of adaptable, deployable entry placement technologies (ADEPT)
- Requires novel thermal protection system (TPS)
- Low ballistic coefficient → more benign entry conditions

BLAM Testing
- Bi-axial load aerothermal mechanical (BLAM) testing
- Evaluate woven TPS under entry conditions
- Model: Heat Flux on Fabric (W/cm²) | Warp Running Load (N/cm) | Weft Running Load (N/cm) | Exposure Time (sec)
  - B1: 136 1310 660 35
  - B2: 97 660 330 135
  - B3: 97 1310 660 139

Mechanical Testing
- Instron 5569, ε = 1mm/min
- Fabric and yarns, pre and post aerothermal exposure

Observations
- Post-exposure strength exceeds flight requirement
- Brittle failures in post-exposure fabrics
- Reduction in mechanical properties correlated with exposure duration

Fabric Test

Results

Yarn Test

Conclusion
- Data indicates that aerothermal heating reduces mechanical strength
- Arcjet exposure appears to cause sample embrittlement
- Mechanical testing provides design guidelines for future woven TPS

Forward Work
- Investigate the causes of embrittlement and reduction in load bearing capacity due to aerothermal heating
- Isolate effects of oxidation and thermal exposure on mechanical performance
- Additional fabric testing to statistically verify mechanical property reductions

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