Performance of Conformable Ablators in Aerothermal Environments

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1. Background
- Thermal blankets protect space vehicles in areas that reach up to 371 °C (700 °F) upon entry into an atmosphere. They are mainly used for their insulative properties and low density, but their flexibility is also very beneficial.
- Conformable ablators have sparked interest due to their potential to withstand relatively high heating rates (~250 W/cm²) while having the ability to be molded to the desired shape during processing.
- Conformable ablators consist of a felt base (such as carbon felt) and a resin, which, upon curing, shows good thermal insulative properties at heating rates of 200 W/cm² or higher.
- The density of conformable ablators depends on the density of the felt used and concentration of resin, but is usually in the range of 0.20 g/cm³ to 0.30 g/cm³.
- Conformal heatshields offer several advantages compared to rigid heatshields, including potential lower thermal conductivity, lower thermal stresses, lower risk of failure due to crack growth, and ease of installation.
- Conformal heatshields are probably less expensive, since they can be made in one piece compared to tiles for a rigid heatshield.

2. Conformable Ablator Processing
- Carbon felt is impregnated with a resin mixture.
- The cured ablator is then dried in a vacuum oven.

3. Importance of Morphology in Ablator Systems
- Morphology refers to the microstructure of an ablator system and the location of phenolic polymer (or infiltrant) relative to the fiber substrate used.

4. Focus of This Work
1. Test several conformable ablators in the same aerothermal environment and evaluate their performance.
2. Down select to two conformable ablators that will be further tested and evaluated to compare their performance in an aerothermal environment and their thermal and mechanical properties.
3. Down select to one conformable ablator that will be advanced to TRL 5 or 6 by end of 2013.

5. Conformable Ablators Investigated
Two carbon felts, made by FMI (Fiber Materials, Inc.) and Morgan AMST, were used to make the conformable ablators in the tests on the right. Morgan’s felt was flat and had no wrinkles, while FMI’s carbon felt was not completely flat and had wrinkles on one side of the felt.

6. Mechanical Properties of Conformable Ablators
Stress Strain Curves of Conformable Ablators with Phenolic Resin

7. Arc Jet Data on Conformables
Results from 20 second exposure

8. Future Work
Samples C and F have been made in a geometry that conforms to part of a cone and be exposed to 250 W/m² in the IHiF at NASA Ames Research Center for further analysis.

9. Summary
- Although the FMI felt with phenolic and an additive (sample D) had the best mechanical properties and the least recession, it was not selected for further testing because of concerns with manufacturing large pieces.
- The high phenolic loading in the Morgan felt (sample C) was responsible for the low recession and low change in the backface temperature.

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