Progress in Manufacturing & Characterizing Domestic Lyocell PICA (PICA-D) and Comparison to Heritage PICA

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1. Background – PICA and PICA Sustainability

State of the Art Low Density Carbon Phenolic Ablators

- Phenolic impregnated Carbon Ablator (PICA) is a low density (~ 0.27 g/cm³) ablator first used as the forebody heatshield for the Stardust sample return capsule where it was used as a single piece heatshield
- Since Stardust, PICA was used on the Mars Science Lab (MSL) in a tiled configuration, on the OSIRIS Rex sample return capsule as a single piece and slated for Mars 2020 as a tiled configuration
- In 2016 NASA ARC learned that the heritage rayon utilized in PICA was stopping production, leading to a flight-qualified PICA sustainability challenge
- In FY16/17, NASA ARC was funded by SMD/PSD to address PICA rayon sustainability
- Lyocell Based PICA (PICA-D) was manufactured and limited testing performed showing it to be a good candidate as a potential replacement for heritage rayon

2. Establishment of PICA-D as a Replacement for Heritage PICA

- In FY17, SMD-PSD funded ARC to manufacture and perform limited property and aerothermal characterization of Lyocell-based PICA
  - FY17 task successfully completed limited testing that indicated the viability of PICA-D as a potential replacement for heritage PICA

Material Property Characterization

- In FY17, 3 billets of PICA-D were manufactured to support testing
  - Limited in-plane (IP) tension, through-thickness (TT) tension, and through thickness thermal conductivity at 100°F and 350°F were conducted and compared to heritage rayon PICA
- Overall these results are in family with production rayon PICA – however additional testing is needed as only a few coupons were evaluated
  - Limited property data had substantial scatter – detailed testing planned for FY18/19

Mechanical Property Comparison

- Average Lyocell properties: 0.28
  - Billet ID: 1
  - Specimen ID: Thermal Conductivity (W/m-K: 0.45-0.47, 0.31-0.32)

3. Establishment of PICA-D Expanded Capability

- 9 billets of FiberForm were manufactured in FY17 to optimize the process using Lyocell fibers
  - Billets spanned the spec density range and billet FiberForm target densities were achieved
- Development and fabrication of 3.08 m net-shaped FiberForm heatshield blank (OSIRIS Rex scale) were also completed in FY17
  - Density targets in all 3 net cast blanks were achieved
- Process refinements and lessons learned have been documented
  - Limited Non Destructive Evaluation (NDE) completed on the Lyocell near net shape FiberForm unit to evaluate fiber alignment and check for off-nominal features
- FY18/19 work will expand on the work performed in FY17 and demonstrate repeatability as well as increase single piece net cast dimensions to >1.2 m

4. Exploration of Lyocell PICA (PICA-D) for Future Missions

In FY18/FY19, NASA Ames is leading an effort funded by SMD-PSD to characterize and extend the capability of PICA-D to establish Lyocell PICA as a Drop-in Replacement for Heritage PICA

- Establishing PICA-D as a “drop in replacement” will allow missions to depend on and design missions with PICA without any risk typical of a replacement.
- Establishing the extended capability of PICA-D will allow Sample Return Missions with higher entry speed that were not considered before.

Task 1: Establish PICA-D as a Drop-in Replacement for Heritage PICA
  - Develop comprehensive material property database
    - Perform comprehensive material property testing (range of temperatures) for thermal and mechanical properties
  - Perform comprehensive arcjet test campaign
    - Test at multiple conditions, including different material lots
    - Testing to include thermal response, instrumented stagnation and wedge shear coupons
  - Develop PICA-D Thermal Response Model utilizing arcjet test data and new material property database

Task 2: Establish the Expanded Capability (Extensibility) of PICA-D
  - Demonstrate Manufacturing and Scale-Up of a Single Piece Heatshield at a Scale of >1.2 m
    - Perform comprehensive characterization and evaluation of single piece FiberForm casting
    - Characterize fiber alignment, mechanical properties and non-destructive evaluation (NDE)
  - Establish Expanded Design Space of PICA-D
    - Perform arcjet testing and heat flux / pressure conditions beyond which PICA has previously been tested and / or flown
  - Publish all PICA-D Data for current and future missions

5. PICA-D Project Schedule

- NASA ARC is working with SMD-PSD to address PICA rayon sustainability concerns
- In FY16/17, Lyocell Based PICA (PICA-D) was manufactured and limited testing performed showing it to be a good candidate as a potential replacement for heritage rayon
- Establishing PICA-D as a “drop in replacement” will allow missions to depend on and design missions with PICA without any risk typical of a replacement.
- Establishing the extended capability of PICA-D will allow Sample Return Missions with higher entry speed that were not considered before.

6. Summary

Acknowledgements

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