10.3.8 Ceramic Matrix Composites (Continuous Fiber Reinforced) Thermal Protection Systems

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SPACE TRANSPORTATION MATERIALS AND STRUCTURES TECHNOLOGY WORKSHOP

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CERAMIC MATRIX COMPOSITES
[CONTINUOUS FIBER REINFORCED]
THERMAL PROTECTION SYSTEMS

BACKGROUND

- Initiated program with American Inc. to develop continuous fiber reinforced CMC thermal protection materials based on silicon carbide
- Reticulated low density ceramic foam core panel structures, based on silicon carbide, were fabricated and evaluated
- Reticulated silicon carbide low density foam susceptible to thermal shock
- "TOPHAT" thermal protection system utilizing a continuous fiber reinforced CMC and reusable surface insulation developed
- Single-ply/multi-ply continuous fiber reinforced silicon carbide CMC successfully evaluated, in the "TOPHAT" thermal protection system, to 3100° F

BACKGROUND cont.

- The carbon reinforced CMC material showed little degradation after a 100 minute exposure to surface temperatures of 2000° F and 2700° F
  - ⋆ The carbon reinforced CMC material showed little change in physical property after 100 minutes exposure to surface temperatures of 2000° F and 2700° F

CERAMIC MATRIX COMPOSITES
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THERMAL PROTECTION SYSTEMS

TECHNOLOGY NEEDS

- o Fabrication Methods / Processes (silicon carbide based systems)
  - ⋆ Large Components
  - ⋆ Architecture
  - ⋆ Costs

- o Material Property Data Base
  - ⋆ Fatigue (loaded, unloaded, thermal, isothermal)
  - ⋆ Baseline Thermal/ Mechanical Properties
  - ⋆ Environmental Effects
    - • Aero-acoustic (with/without shock impingement)
      - – sound levels in excess of 170 db
      - – oscillating pressure (1-5 psi peak to peak)
    - • Particle Impact
    - • Water Adsorption/Absorption

- o Attachment Techniques
  - ⋆ Integral Structure / TPS
  - ⋆ Hot Structure
  - ⋆ Warm Structure
  - ⋆ Seals

- o Non-Destructive Evaluation
  - ⋆ Quality Assurance
  - ⋆ Flaw / Separation Detection

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THERMAL PROTECTION SYSTEMS

TECHNOLOGY GAPS

- o High Temperature Continuous Fiber Reinforced CMC Materials
  - ⋆ Temperatures > 3500° F
    - o High Strength / High Temperature Fibers
      - ⋆ Property Retention At Temperatures > 2200° F
    - o High Temperature / High strength Matrices
      - ⋆ Property Retention At Temperatures > 2200° F

- o Process Developments
  - ⋆ New Processes
  - ⋆ Shorter Fabrication Times

HIGHEST PAYOFF AREAS

- o High Temperature / High Strength Continuous Fiber Reinforcements
  - ⋆ Temperatures > 3500° F
  - ⋆ Strength Retention > 3500° F
    - - High Temperature Strengths Comparable To RT Strengths of present State-of-the-Art Fibers

10.3.9 Thermal Protection Systems for Space Transportation Vehicles by Howard Goldstein, NASA ARC