PROCESSING AND CHARACTERIZATION OF BASALT FIBER REINFORCED CERAMIC COMPOSITES FOR HIGH TEMPERATURE APPLICATIONS USING POLYMER PRECURSORS

SARAH COX, DONOVAN LUI, JIHUA GOU

COMPOSITE MATERIALS AND STRUCTURES LABORATORY, DEPARTMENT OF MECHANICAL ANDAEROSPACE ENGINEERING

UNIVERSITY OF CENTRAL FLORIDA, ORLANDO, FL 32816

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CONTINUOUS BASALT FIBER REINFORCED POLYMER DERIVED CERAMICS HAVE BEEN FABRICATED AND TESTED FOR THE APPLICABILITY OF THIS COMPOSITE SYSTEM AS A HIGH TEMPERATURE STRUCTURAL COMPOSITE MATERIAL.

ABSTRACT

The development of high temperature structural composite materials has been very limited due to the high cost of the materials and the processing needed. Ceramics can take much higher temperatures, but they are difficult to produce and form in bulk volumes. Polymer Derived Ceramics (PDCs) begin as a polymer matrix, allowing a shape to be formed and cured; it is then pyrolized in order to obtain a ceramic with the associated thermal and mechanical properties. Polysiloxanes are PDCs which contain a silicon oxycarbide backbone when pyrolized up to 1000°C. The use of basalt in structural and high temperature applications has been under development for over 50 years, yet there has been little published research on the incorporation of basalt fibers as a reinforcement in composites. Basalt is a naturally occurring material found in volcanic rock. Basalt is a good alternative to glass and carbon as reinforcement. Basalt fibers are around the same cost as glass fibers, but they have mechanical and thermal properties similar to carbon fibers. Continuous basalt fiber reinforced PDCs have been fabricated and tested for the applicability of this composite system as a high temperature structural composite material.

PANEL FABRICATION

Materials

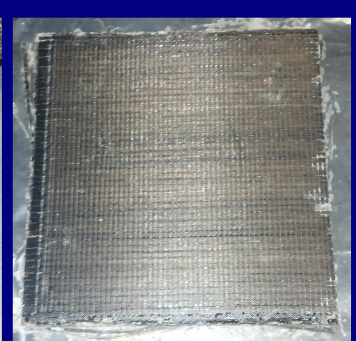
- SPR-688 is a polysiloxane manufactured by Starfire Systems
  Polysiloxanes contain a silicon oxycarbide backbone when pyrolized up to 1000°C.
- Continuous Biaxial Basalt Fabric is used with the layup $[0/90]_{12}$

Fabrication

- 6” x 6” Panels cured to 100°C, then postcured to 275°C
- Panels pyrolyzed in a kiln up to 850°C

Biaxial Continuous Basalt Fiber

Wet Layup with Polysiloxane Resin



Panel after Cure

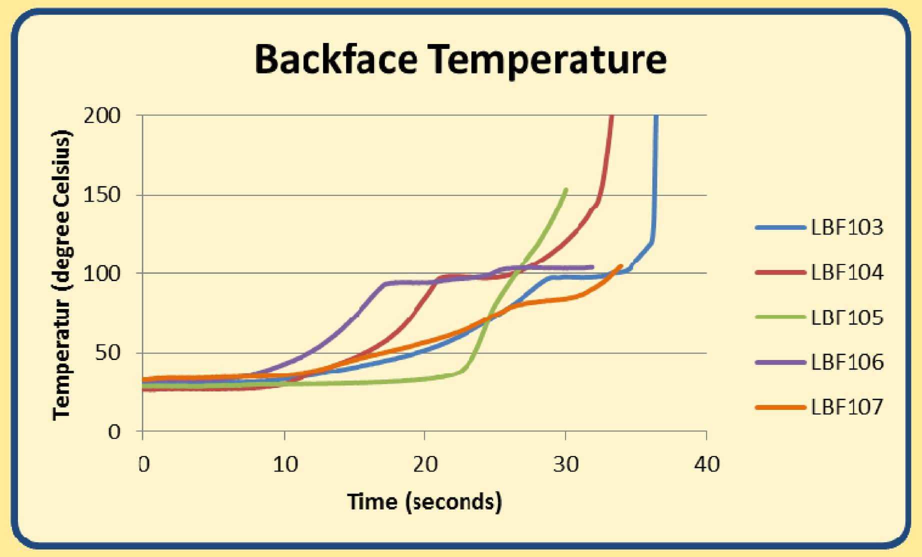
ABLATIVE TESTING

Testing performed referencing ASTM E-285

- 5 panels were tested
- Oxyacetylene torch used with a heat flux of 835 W/cm²
- Thermocouple measurements recorded on the back of the panel at the penetration point
- Testing terminated at complete burn through

PANEL AND TESTING DATA

PANEL	Fiber Volume Fraction	Initial Weight (g)	Post Weight (g)	Mass Retained	Resin Retained	Erosion Rate (in/sec)
LBF103	67.87%	245.20	232.10	94.66%	76.27%	0.0074
LBF104	72.78%	282.30	263.10	93.20%	69.28%	0.0071
LBF105	70.42%	283.90	263.90	92.96%	70.54%	0.0083
LBF106	72.94%	276.30	257.30	93.12%	69.00%	0.0081
LBF107	72.11%	279.30	260.00	93.09%	69.61%	0.0076



RESULTS

- Burn through occurred around 30-35 seconds into testing
- Maximum temperature seen by the back face prior to burn through: 180°C
  - LBF106 and LBF107 had the thermocouple slightly off center, which gave lower values

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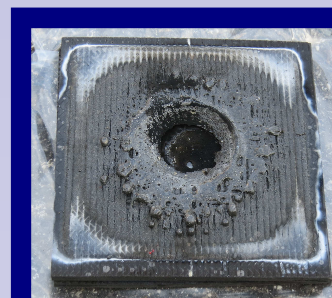
Ablation Testing

Test Set Up



LBF103 Front of Panel

LBF103 Back of Panel

LBF103 Side of Panel

LBF106 Front of Panel

LBF106 Back of Panel

LBF106 Side of Panel

CONCLUSIONS

- Fabrication of high temperature composites has been performed using polysiloxane and continuous basalt fiber
- Ablative testing shows promising results for high temperature applications

FUTURE WORK

- Reinfiltration pyrolysis cycles of panels to increase ceramic content
- Perform mechanical testing (bending)
- Fabrication of alternate layups [±45/0/90] to increase impact resistance and mechanical strength

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