Ceramic/Metallic Heat Exchanger Development

10th Annual SECA Workshop
Pittsburgh, PA
July 12, 2009

Acumentrics Corp.
20 Southwest Park
Westwood, MA
Uninterruptible Power Supplies for Harsh Environments

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- Cathodic Protection
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Ceramic/Metallic Heat Exchanger Development

**Project Objective**

- Combine ceramic and metallic heat exchanger cores to produce a low cost, high effectiveness, recuperator for cathode air preheating
Recuperator Specification

• Exhaust Inlet Temperature – 850 - 950 C
• Air Outlet Temperature – 725 - 800 C
• Effectiveness – >85%
• Total Pressure Drop – 1250 Pa
• Equal Air and Exhaust Flowrates
• Air Flow – 150 lpm per kWe
Stack/Recuperator Layout

Cross Flow Ceramic Section

Exhaust (Shell side)

Air (tube side)

Counter Flow Metallic Section
Recuperator Configuration

- Exhaust Plenum
- Counter Flow
- Metallic Core
- Exhaust Inlet
- Casing
- Expandable Ceramic Fiber Gasket
- Ceramic Cross Flow Core
- Exhaust Cross-over
- Air Out
- Exhaust In
Ceramic Cores Manufactured by Blasch Precision Ceramics

<table>
<thead>
<tr>
<th></th>
<th>Passage Width (mm)</th>
<th>Heat Transfer Area (cm^2)</th>
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</thead>
<tbody>
<tr>
<td>Core 1</td>
<td>7.0</td>
<td>810</td>
</tr>
<tr>
<td>Core 2</td>
<td>3.3</td>
<td>1425</td>
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</tbody>
</table>
Hybrid Cross/Counter Flow Flow Recuperator
# Recuperator Performance

<table>
<thead>
<tr>
<th>Air Flow</th>
<th>Ovl Effectiveness</th>
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<tbody>
<tr>
<td>slpm</td>
<td>Metallic (Folded Sheet)</td>
</tr>
<tr>
<td></td>
<td>Hybrid (Core #1)</td>
</tr>
<tr>
<td>100</td>
<td>0.71</td>
</tr>
<tr>
<td>200</td>
<td>0.71</td>
</tr>
<tr>
<td>300</td>
<td>0.70</td>
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Ceramic Core Performance Testing
Ceramic Monolith Performance

- Air Inlet Temperature (C)
- Air Outlet Temperature (C)

- 200 slpm Core 1
- 300 slpm Core 1
- 200 slpm Core 2
- 300 slpm Core 2
Metallic Sections Tested

- Fin Core
- Folded Sheet
- Shell & Tube
- Foil
Integrated Stack/Recuperator Test Stand
Accomplishments

• Completed the detailed design of a cross flow ceramic / counter flow metallic hybrid recuperator
• Developed heat exchanger models
• Designed and manufactured molds to produce ceramic heat transfer cores
• Manufactured prototype cores
• Manufactured prototype 1 kW hybrid recuperators
• Designed and manufactured various metallic heat exchanger cores
• Conducted performance testing of hybrid recuperators utilizing two different ceramic cores and two different metallic section configurations
• Characterized heat transfer performance of ceramic cores
• Assembled recuperator and integrated stack/recuperator test stands
Future Activities

• Conduct integrated fuel cell stack testing with the hybrid recuperator.
• Evaluate ceramic component manufacturing techniques to optimize the ceramic core heat transfer rates and increase the specific surface area.
• Evaluate scale-up of the heat exchanger geometry to larger generator sizes.
• Evaluate a foil design counter flow metallic section which has the potential to further reduce the recuperator cost.
• Evaluate recuperator designs which are compatible with a “replaceable” fuel cell bundle stack configuration
Acknowledgements

- This work performed under contract DE-FG02-06ER84590
- Thanks to Maria Reidpath and Robin Ames at DOE - NETL
- Thanks to the staff at Blasch Precision Ceramics