Ceramic/Metallic Heat Exchanger Development

10th Annual SECA Workshop

Pittsburgh, PA

July 12, 2009

Acumentrics Corp.

20 Southwest Park

Westwood, MA

Acumentrics
Trusted Power Innovations

Uninterruptible Power Supplies for Harsh Environments

Industrial-UPS®
Commercial

Rugged-UPS®
Military

Acumentrics
Trusted Power Innovations

Tubular SOFC Generators

- Micro CHP
- Cathodic Protection
- Military Power

Acumentrics
Trusted Power Innovations

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

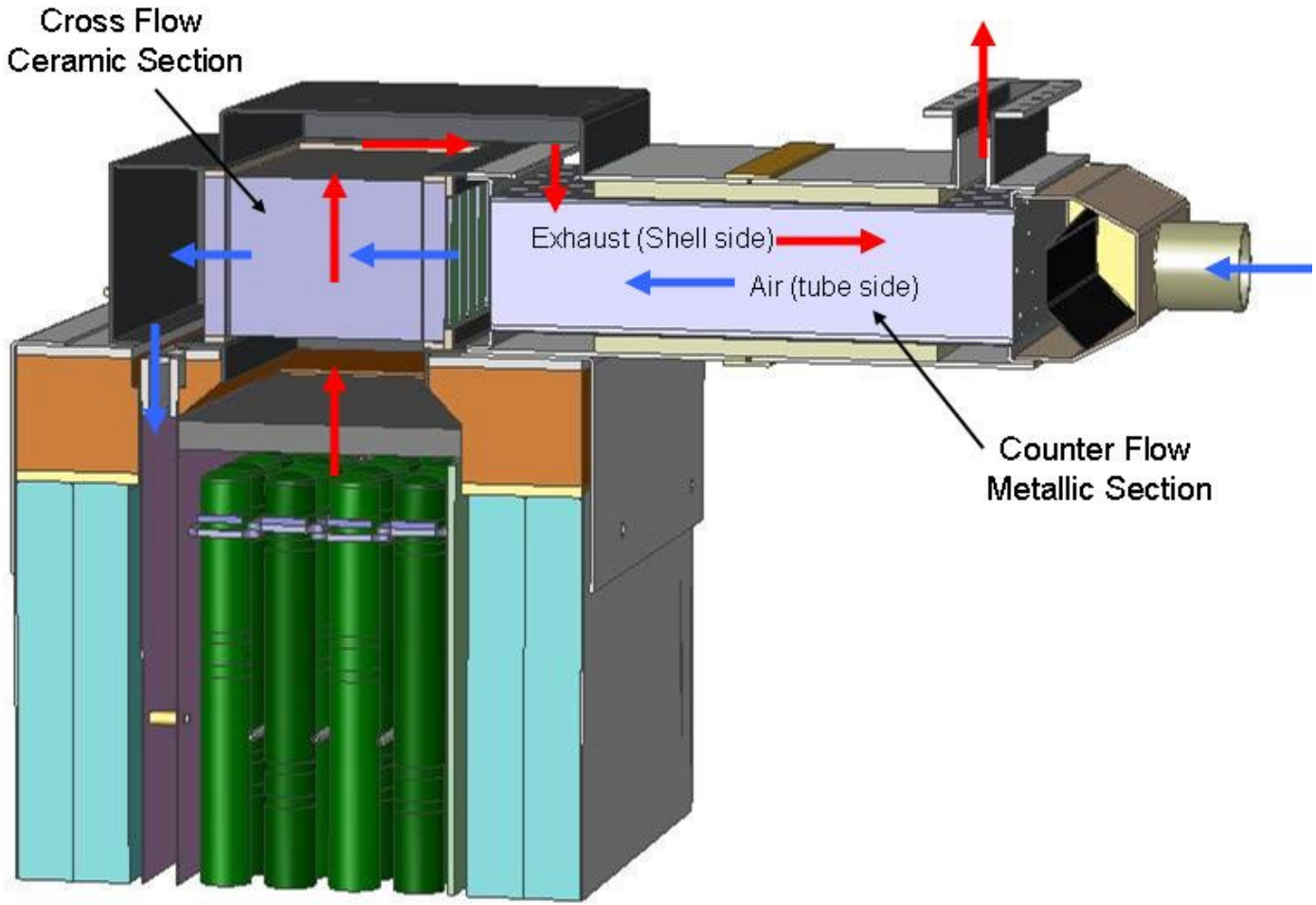
Acumentrics
Trusted Power Innovations

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

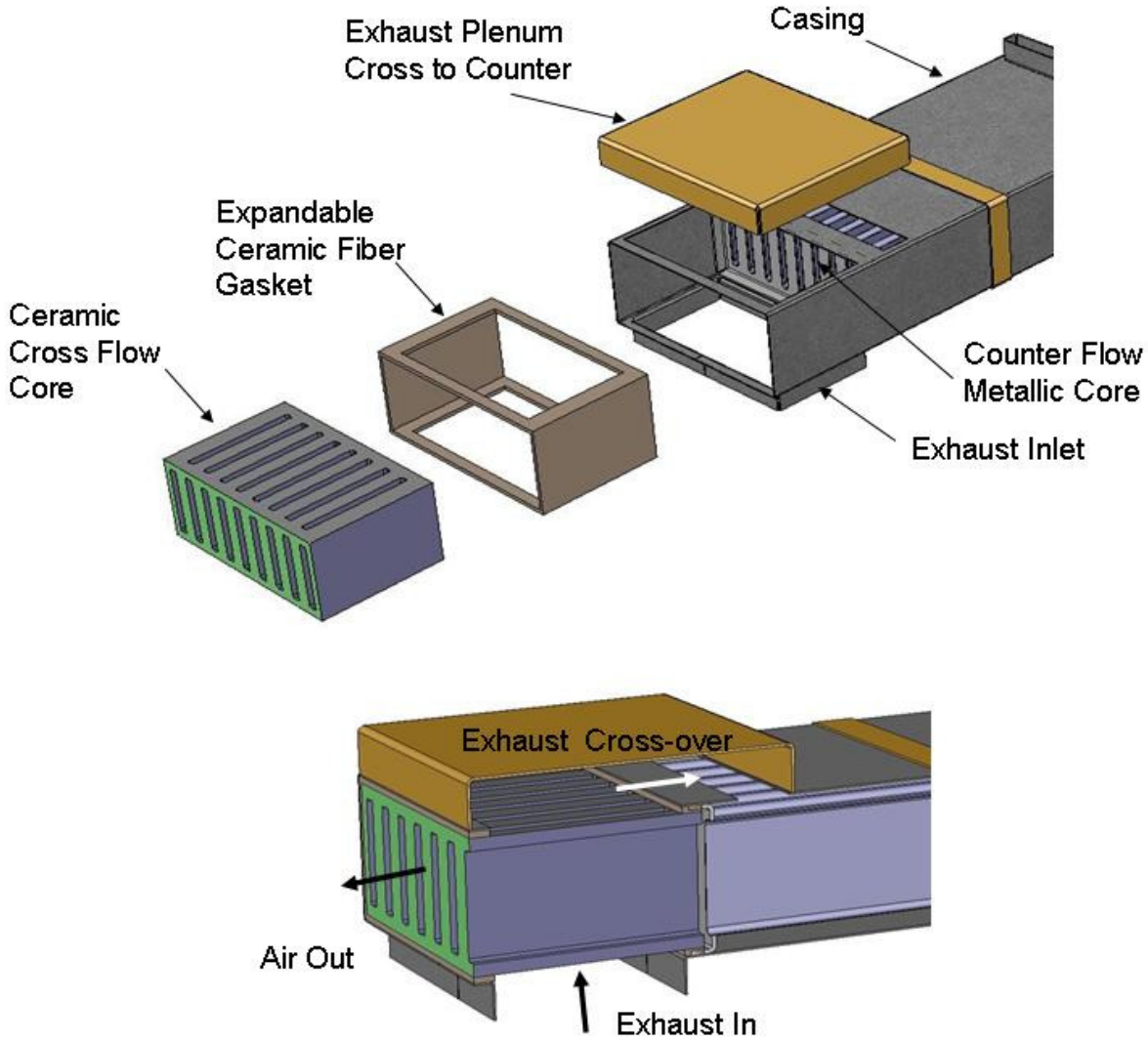
Acumentrics
Trusted Power Innovations

Stack/Recuperator Layout

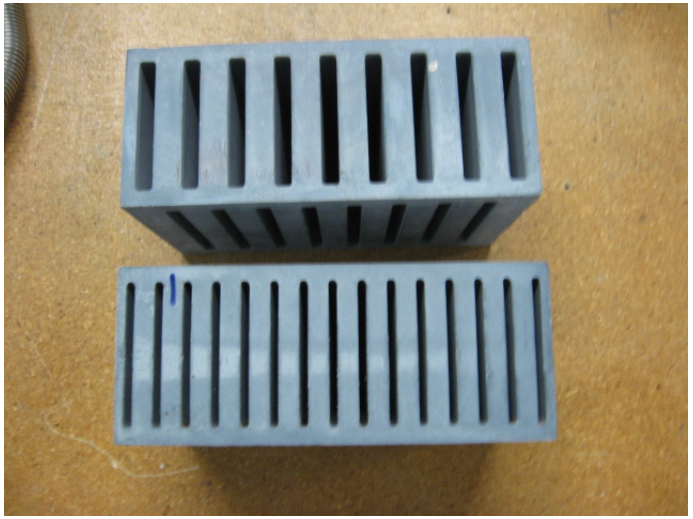


Acumentrics
Trusted Power Innovations

Recuperator Configuration

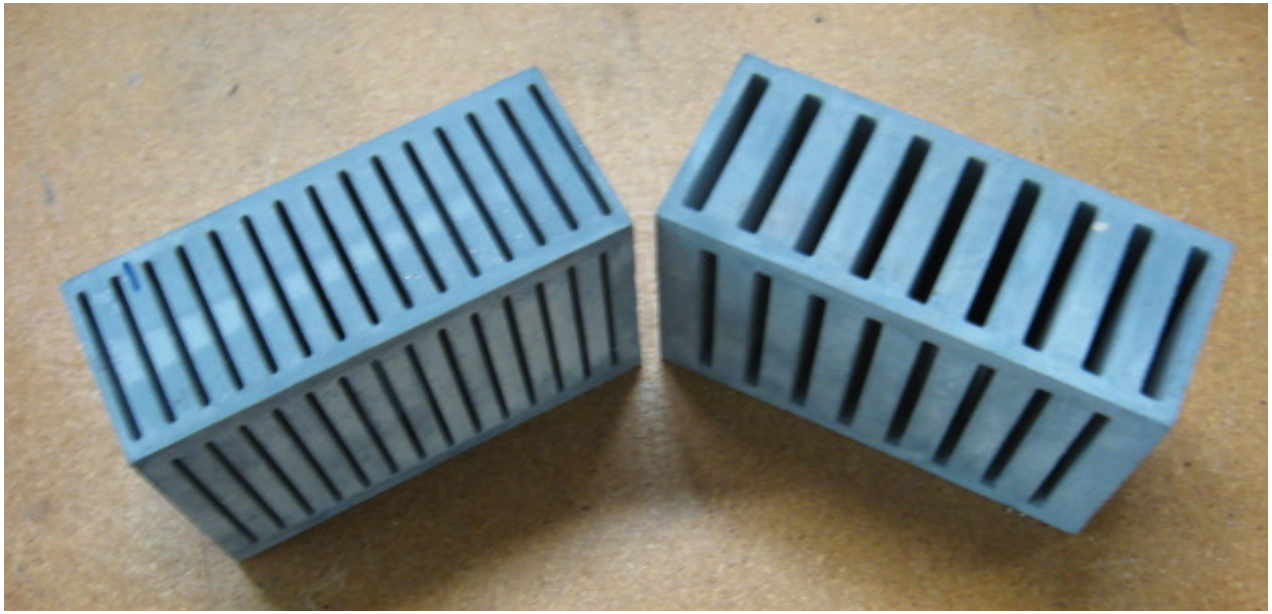


Acumentrics
Trusted Power Innovations



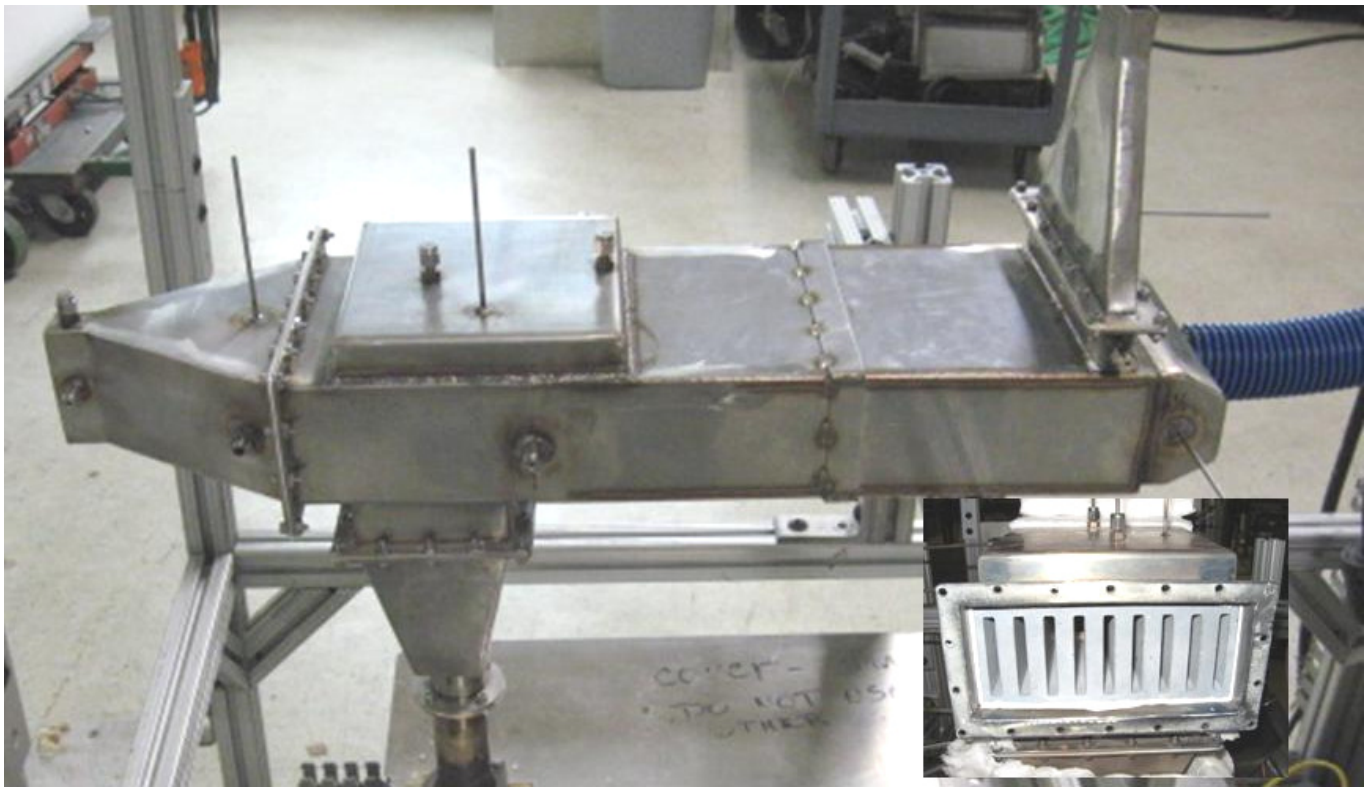
Ceramic Cores Manufactured by Blasch Precision Ceramics

	Passage Width (mm)	Heat Transfer Area (cm^2)
Core 1	7.0	810
Core 2	3.3	1425



Acumentrics
Trusted Power Innovations

Hybrid Cross/Counter Flow Recuperator



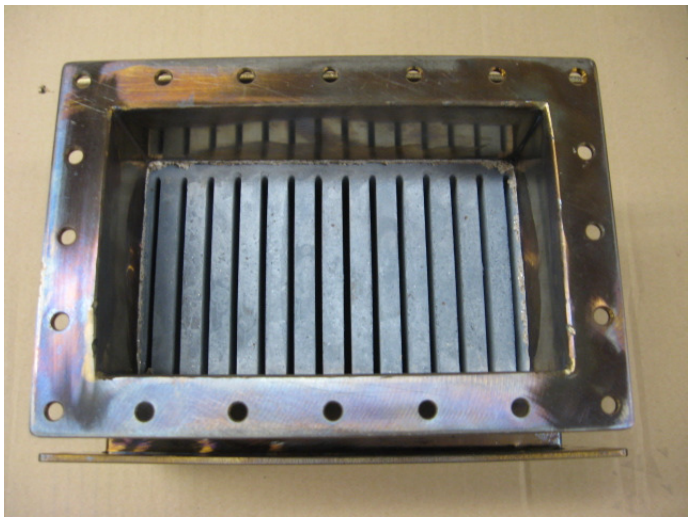
Acumentrics
Trusted Power Innovations

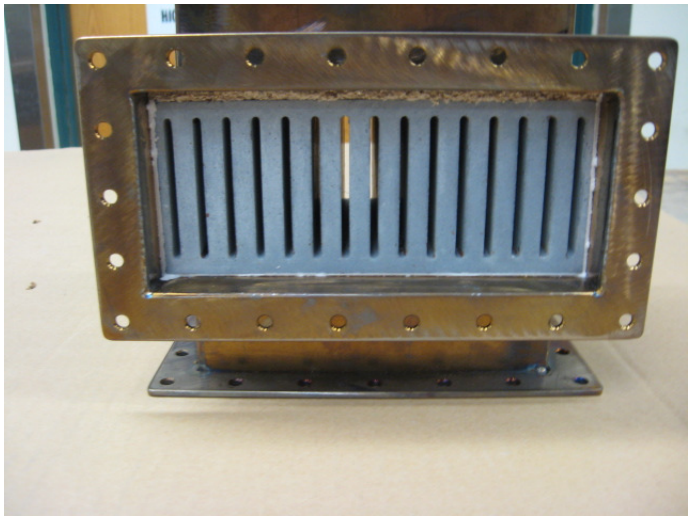
Recuperator Performance

Air Flow	Ovl Effectiveness	
slpm	Metallic (Folded Sheet)	Hybrid (Core #1)
100	0.71	0.79
200	0.71	0.82
300	0.70	0.78

Acumentrics
Trusted Power Innovations

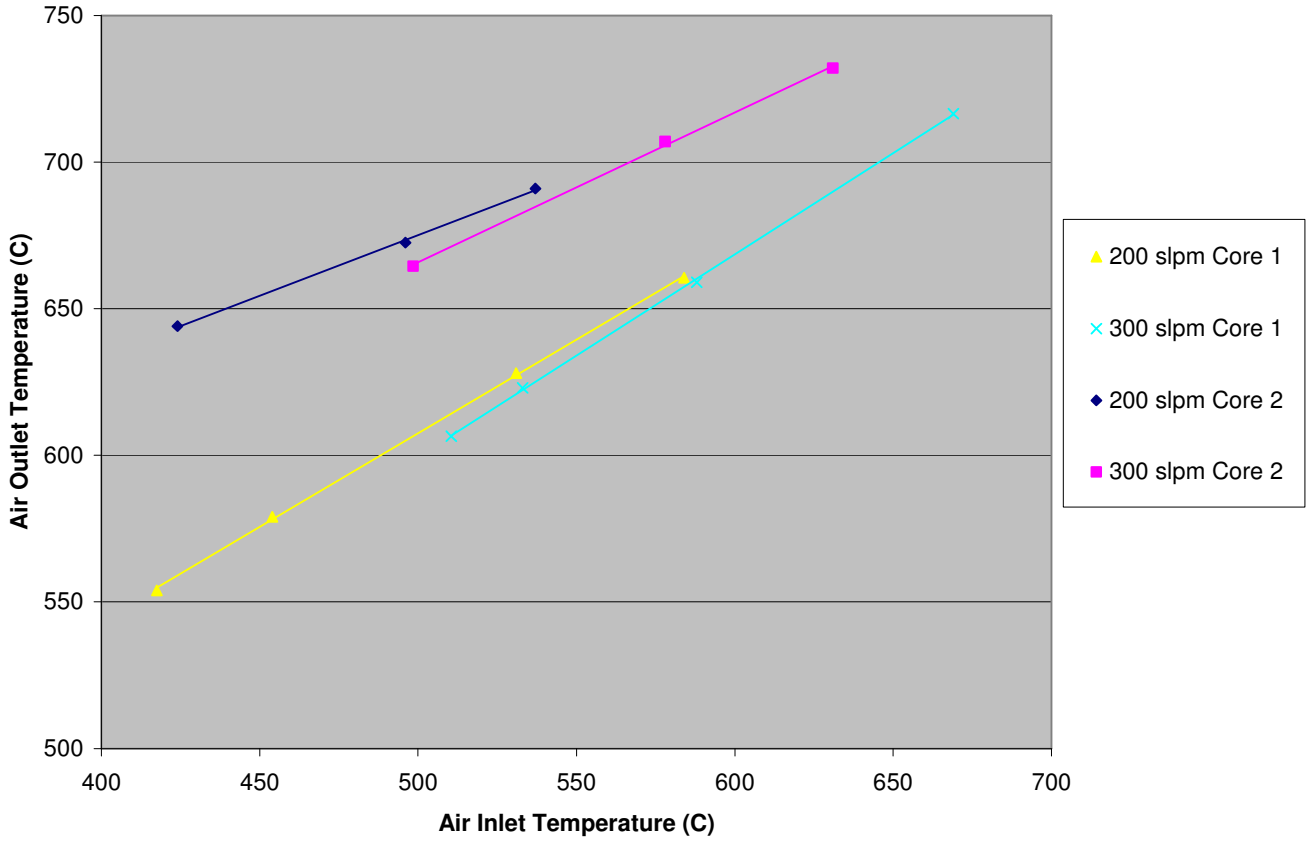
Ceramic Core Performance Testing





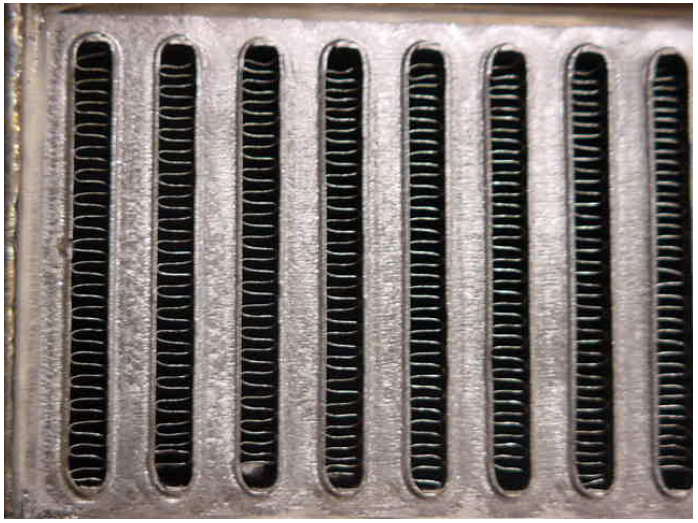
Acumentrics
Trusted Power Innovations

Ceramic Monolith Performance

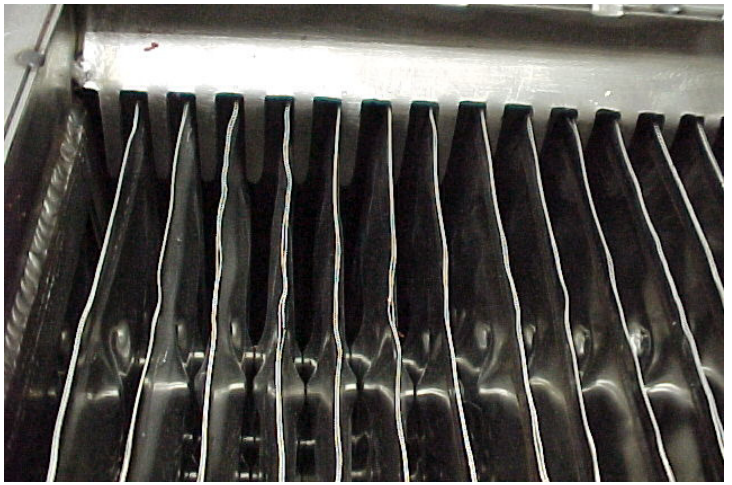


Acumentrics
Trusted Power Innovations

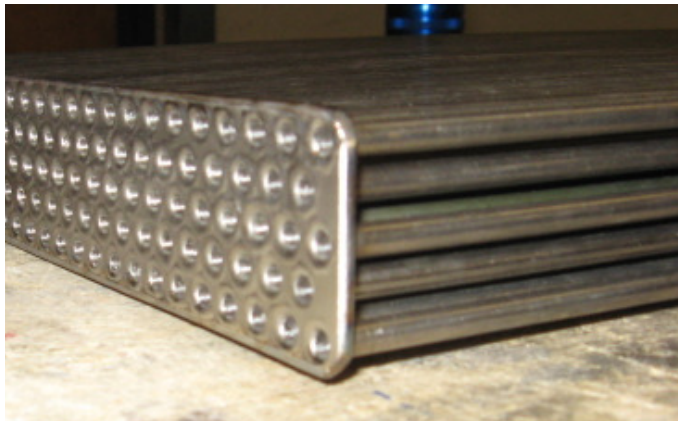
Metallic Sections Tested



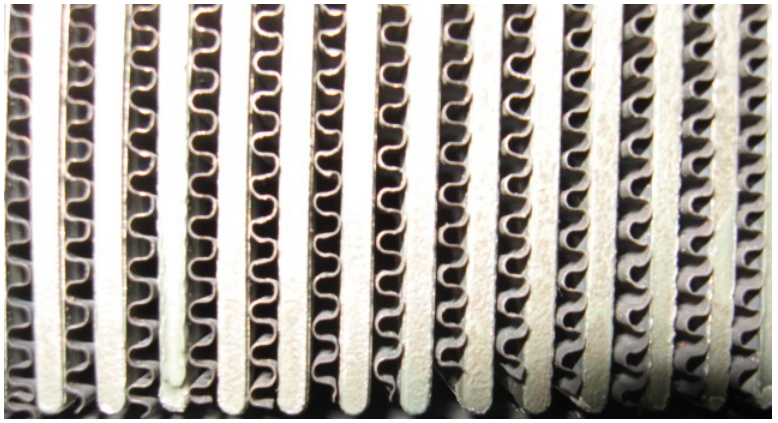
Fin Core



Folded Sheet



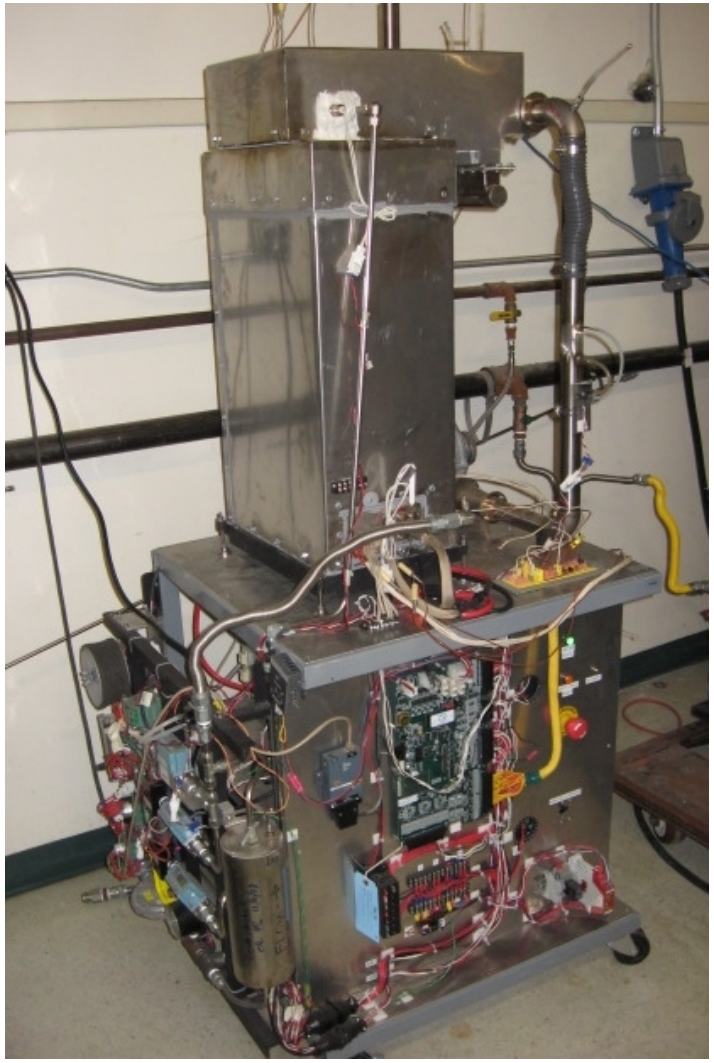
Shell & Tube



Foil

Acumentrics
Trusted Power Innovations

Integrated Stack/Recuperator Test Stand



Acumentrics
Trusted Power Innovations

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

Acumentrics
Trusted Power Innovations

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

Acumentrics
Trusted Power Innovations

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