Catalytic Heat Exchanger for SOFC Balance-of-Plant Cost Reduction

Stephen Jolly, Hossein Ghezel-Ayagh
FuelCell Energy, Inc.

Joseph R. Stevenson
Modine Manufacturing Company

Project Objective
Demonstrate conceptual feasibility of a highly effective catalytic cathode air preheater for a 60kW SOFC power plant to increase plant performance and to reduce the balance of plant cost.

Team Partners
FuelCell Energy, Inc.
BASF Catalysts
Iselin, New Jersey

Project Background
• In addition to SOFC cell/stack performance, cost, and durability improvements – innovative technologies for reducing balance-of-plant (BOP) component costs are required for successful commercial deployment of SOFCs in distributed generation applications.

Typical SOFC-based System

BOP Capital Equipment Cost Breakdown:
Oxidizer and Air Preheater represent the largest opportunity for BOP cost reductions

Simplified System Concept with Multi-Functional Catalytic Heat Exchanger

60-80% cost reduction estimated (in high volume production), compared to conventional separate oxidizer / heat exchanger

Material of Construction Selection

Key Material Selection Criteria:
• Oxidation Resistance
• Suitability for catalyst washcoating
• Joining via conventional methods
• Acceptable creep strength
• Availability
• Cost

Due to HX design features, maximum temperature is limited to ~770 °C. Therefore, high-Ni Super Alloys are not required.

Conceptual Catalytic Heat Exchanger Design for 60kW SOFC Power Plant

Oxidation Catalyst Washcoated onto Metallic Substrate
Anode Off-gas
Cathode Exhaust

Typical Oxidation Catalysts for SOFCs:
• YSZ
• Lar cathode

Sensitivity Study: Levelized Cost of Electricity (LCOE) vs. Catalytic HX Pressure Drop Specification

• As fuel prices decrease from $8/MMBtu to $3/MMBtu, optimal dP specification increases from <6 to 25"H2O

Lab-Scale (3kW) Catalytic Heat Exchanger Design and Fabrication

Anode Exhaust Gas (Fuel)
Cathode Exhaust Gas

Previsions for thermocouples at each inlet and outlet, in addition to 3 thermocouples to map shell-side temperatures

Lab-Scale Catalytic Heat Exchanger Testing Results

• Maximum combustion temperature was well-controlled
• No temperature runaway observed
• Maximum combustion temperature is effectively moderated even up to 2x the design fuel flow rate
• Hot-in to cold-out approach temperatures:
  • 94 °C without fuel flow (non-catalytic mode)
  • 19.4 °C with fuel flow (catalytic mode)
• Heat duty:
  • As tested = 2.85 kW (test facility maximum temperature limited)
• Total pressure drop at Normal Operating Conditions = 7.8 "H2O (below 10 "H2O target)

This material is based upon work supported by the Department of Energy under Award Number DE-SC00100262