High Performance Catalytic Heat Exchanger for SOFC Systems

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Efficient utilization of our nation's fossil and renewable energy sources is a top priority to secure a sustainable energy future. Solid Oxide Fuel Cell (SOFC) based power systems represent an emerging technology that have the potential to produce clean electric power at nearly twice the efficiency of small-scale combustion engines and to nearly eliminate the release of NOx and SOx to the environment. Recuperation of heat at high temperatures (up to 900°C) is a crucial component of an SOFC system. In a typical SOFC system, hot effluent gas from a catalytic combustor is piped to the source-side of a high temperature recuperator, preheating fresh air for the cathode. To create a competitive market-entry SOFC product (300kW nominal rating), BOP costs must be reduced. The catalytic combustor and the cathode air preheater represent ≥25% of the BOP cost, and therefore represent the largest opportunity for cost reductions.

FuelCell Energy, Inc. (FCE), in partnership with Modine Manufacturing Company and BASF Catalysts, have teamed up to develop a novel catalytic heat exchanger which combines the functionality of the separate catalytic combustor and cathode air preheater into a multi-functional single unit. Applying this innovative technology to SOFC power systems has the potential significantly reduce BOP costs while also meeting the severe technical design requirements. In addition to the high operating temperature and temperature differentials, the heat exchanger must also be designed to withstand a corrosive environment on the source-side (H2O, O2), thermal cycling, and impart very low pressure drop on both the source and sink sides. Low cost is also a key criterion for design of the cathode air preheater. This research and testing program is anticipated to address critical design challenges through multidisciplinary design optimization and lab-scale component testing. As part of the current Phase I program, the conceptual engineering and design of a 300kWe-sized catalytic heat exchanger are being developed. A capital and lifecycle cost analysis will be performed to quantify BOP cost savings. To validate design features, a laboratory-scale catalytic heat exchanger will be designed, fabricated and tested in FCE's facilities operating under simulated system conditions. This research is being performed under a Phase I DOE-sponsored Small Business Innovation Research (SBIR) grant.