the ENERGY lab

PROJECT FACTS

Fuel Cells

Techno-Economic Analysis of Scalable Coal-Based Fuel Cells—University of Akron

Background

In this congressionally directed project, the University of Akron (UA) will develop a scalable coal fuel cell manufacturing process to a megawatt scale. UA has demonstrated the technical feasibility of a laboratory coal fuel cell that can economically convert high sulfur coal into electricity with little negative environmental impact.

This project is managed by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL), whose mission is to advance energy options to fuel our economy, strengthen our security, and improve our environment. With the Solid Oxide Fuel Cells (SOFCs) program and systems coordination from the Solid State Energy Conversion Alliance, DOE/NETL is leading the research, development, and demonstration of SOFCs for both domestic coal and natural gas fueled central generation power systems that will enable low cost, high efficiency, near-zero emissions and water usage, and carbon dioxide (CO_2) capture.

Project Description

This project will demonstrate the technical and economic feasibility of building a 250 kilowatt (kW) direct coal fuel cell (DCFC) pilot plant. Researchers at the UA have demonstrated the technical feasibility of a laboratory coal fuel cell that can economically convert high sulfur coal into electricity with near-zero negative environmental impact. Scaling up this coal fuel cell technology to a megawatt scale requires two key elements: (1) developing the manufacturing technology for the components of the coal-based fuel cell and (2) long-term testing of a kW-scale fuel cell pilot plant. This novel coal fuel cell technology is expected to be a highly efficient, super clean, multi-use electric generation technology, which promises to provide low cost electricity by expanding the utilization of U.S. coal supplies and relieving our dependence on foreign oil.

A DCFC stack consists of multiple fuel cells that are interconnected electrically to one another. The performance of the stack will be simulated on the basis of preliminary design and the single cell performance. The simulations and test data will be used to further refine the design.

Goals and Objectives

The ultimate goal of this project is to demonstrate the technical and economic feasibility of building a 250 kW pilot plant coal fuel cell. This project will address initial development, scaling, and manufacturing of the core technology as follows:

- Design a kW-scale fuel cell system and simulate its performance.

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PARTNERS

None

PROJECT DURATION

Start Date	End Date
09/01/2009	08/31/2013

COST

Total Project Value
$1,713,961

DOE/Non-DOE Share
$1,370,977/$342,984

AWARD NUMBER

FE0000528

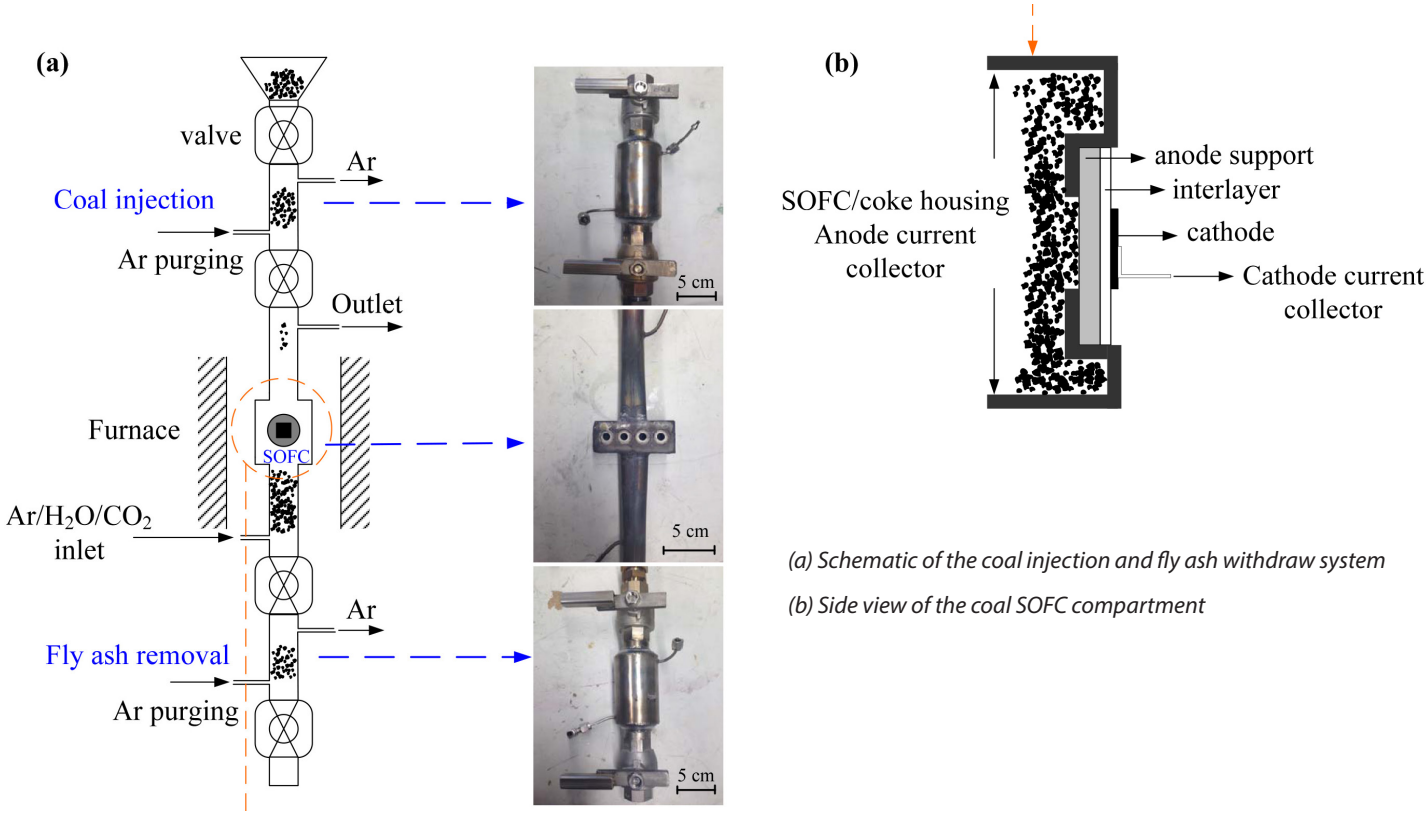
- Develop a kW-scale fuel cell manufacturing technology.
- Evaluate the durability of the kW fuel cell components.
- Develop low cost interconnect and the cathode current collector materials.
- Design a coal injection and flyash withdraw system.
- Design a 250 kW fuel cell pilot plant.

Accomplishments

- Synthesized and characterized a copper-nickel-yttria-stabilized zirconia (Ni/YSZ) anode that exhibits high catalytic activity for electrochemical oxidation of carbon and hydrocarbons, and resistance to deactivation.
- Developed a tape casting formulation that facilitates the fabrication of fuel cells with variable anode porosity and high mechanical strength.
- Simulated the steady-state operation of a 250 kW coal-based system determining mass/energy balances and energy efficiencies.
- Identified and tested suitable ceramic and glass-ceramic sealant materials for the operation of a coal-based fuel cell, demonstrating leakage rates as low as 0.17 standard cubic centimeters per minute per centimeter, and matching the performance of alternative compression seals.
- Designed and tested a coal injection and fly ash removal reactor.
- Flowing trace amount (2% or less) of H_2, CO_2, and H_2O improves the performance of coke fuel cell.
- Exposure of coke to 3 mol% H_2 keeps the anode in reduced state and promotes formation of CO and CH_4.
- Exposure of coke to 7 mol% H_2O (steam) improves the performance of the SOFC with coke as the feed. This improvement is due to the H_2 and CO_2 generation via water gas shift reaction and coke gasification.
- Assembled and successfully tested five Ni/YSZ anode-supported fuel cells in series, generating 4.6 open circuit voltage.

Benefits

The UA project assists the SOFCs program in meeting its cost and performance targets by ensuring that SOFCs can achieve reliable operation over an extended operating life. The program will ultimately enable fuel cell-based near-zero emission coal and natural gas power plants with greatly reduced water requirements and the capability of capturing 97 percent or greater of carbon at costs not exceeding the typical cost of electricity available today. Achieving this goal will significantly impact the nation given the size of the market, the expected growth in energy demand, and the age of the existing power plant fleet. It will also provide the technology base to enable grid-independent distributed generation applications. Federal funding support of this research is appropriate given the game-changing nature of the technology accompanied by risks higher than the private sector initially can accept.



(a) Schematic of the coal injection and fly ash withdraw system

(b) Side view of the coal SOFC compartment