R & D facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Sensors and Control

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Responsive Fuel Control Hardware

Objective(s)

Develop responsive fuel control hardware for fine tuned control of advanced power systems.

Relevancy

Advanced Power systems for the 21st century will be expected to operate at higher efficiency and at or near zero emissions. These systems will likely be a hybrid design integrating state-of-the-art power technologies such as gas turbines and Solid Oxide Fuel Cells (SOFCs), using syngas or (eventually) pure hydrogen as a fuel. To meet performance expectations, at or near zero emissions, will require precision control of the fuel delivery systems and the hot gas paths coupling these technologies.

For state-of-the-art gas turbines, complex flow control strategies use pressure control valves to control flow to one or more manifolds. These manifolds supply fuel to multiple fuel injectors through fixed geometry flow paths. Even though the fixed geometry fuel paths are precision-crafted, the manufacturing variations from nozzle to nozzle can be enough to create unequal local combustion around the annulus of the turbine. The result is compromised performance directly linked to the worst performing local combustor. Maintaining flame stability without compromising performance in modern turbines requires fine tuned control of local combustion.

Likewise, for state-of-the-art fuel cells, the flow is supplied to multiple cells through a common flow manifold, where manufacturing variations in cell flow channels can result in unbalanced flow to individual cells within the stack. Again, stack performance is limited by the worst performing cell, but precision flow control of fuel and oxidizer can improve performance.

Employing conventional valve technology is often cost-prohibitive and not feasible due to space limitations. Developing small, robust, low cost flow control hardware options will facilitate the fine-tuned flow control required in advanced power systems.

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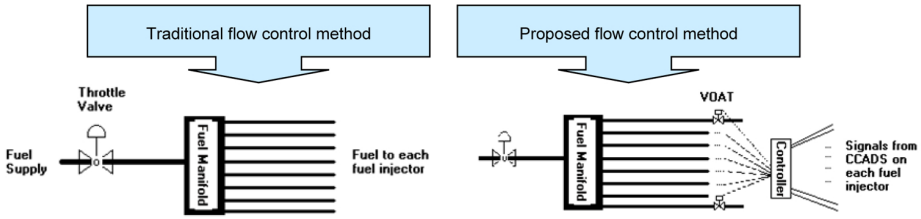
Project Description

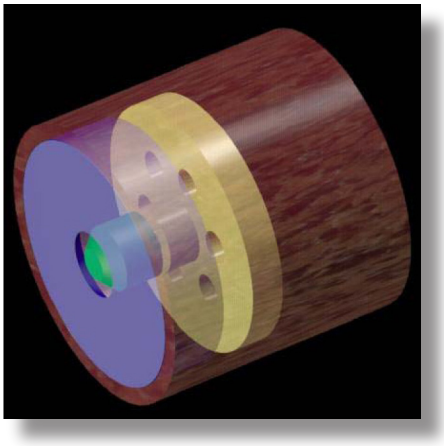
The goal of this project is to develop appropriate small-scale electronically controlled variable orifice technology that can be used as retrofit replacements for current fixed orifice technology, which provide robust fine-tuned local control capability for advanced power systems. Leveraging micro-machining and Micro-Electrical-Mechanical-Systems (MEMS) capabilities small-scaled flow control devices can potentially be manufactured at a fraction of the cost of convention valve technology.



Initial development will focus on a low temperature (150 DEGC) variable orifice for existing dry, low-NOx (DLN) gas turbines, which can also be applied in low temperature, polymer electrolyte membrane (PEM) fuel cells and other continuously fueled systems using a relatively low-temperature fuel supply. The target application is advanced gas turbines in which replacing the fixed orifice can achieve fine-tuned local combustion control.

Concurrent evaluation of advanced materials, such as aluminum nitride, for the fabrication of high-temperature (800 DEGC) actuators is another ongoing part of this development effort. Such actuators would be suitable for use in variable orifice micro-valves for Solid Oxide Fuel Cells (SOFCs), syngas turbines, hydrogen turbines, and other high-temperature continuously fueled systems.

This project is part of NETL's University Research Initiative Program, where experts from West Virginia University, University of Pittsburgh, and Carnegie Mellon University jointly collaborate with NETL to develop these novel devices.



One Variable Orifice Micro-Valve Concept