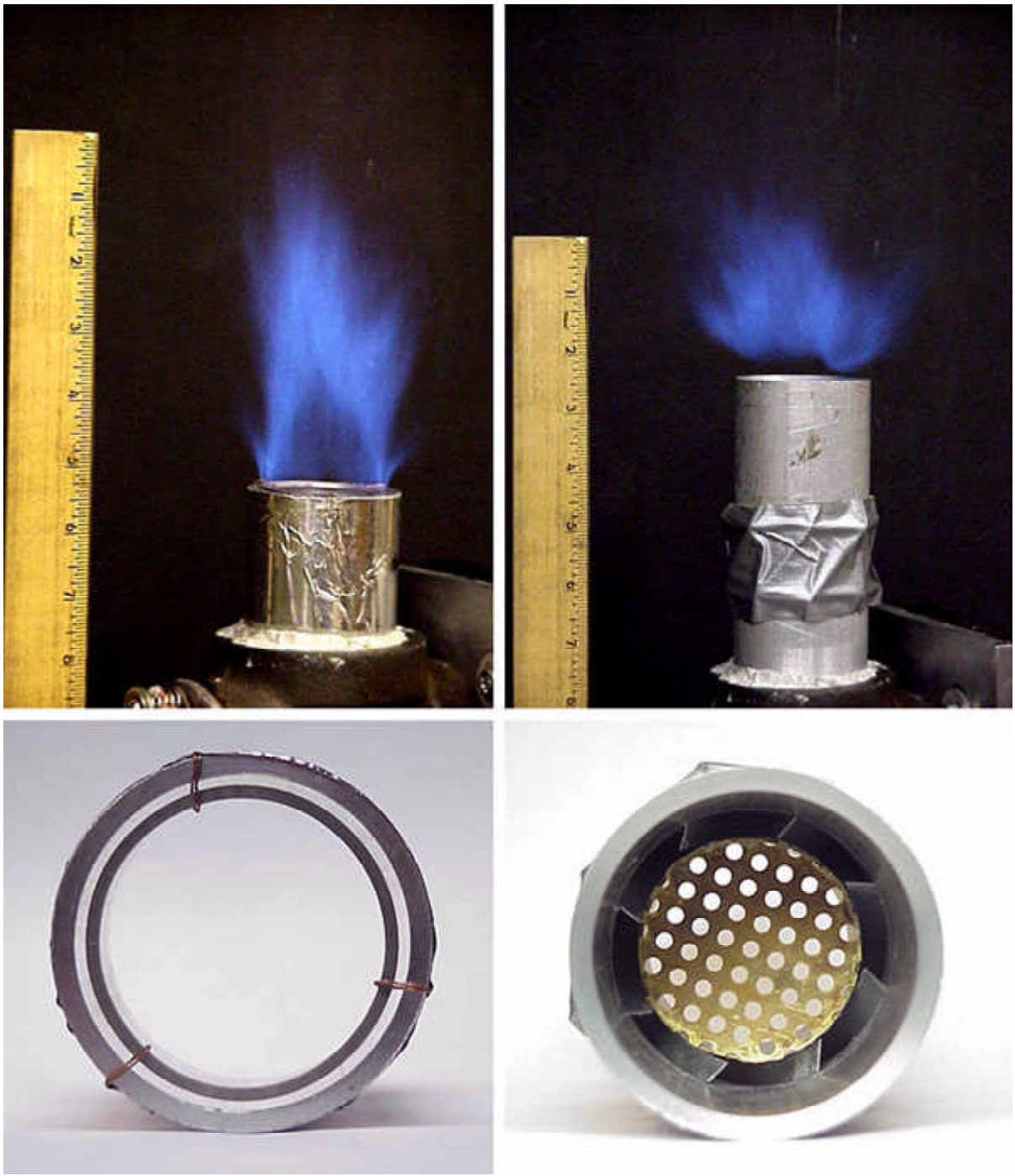
Technology Being Developed at Lawrence Berkeley National Laboratory: Ultra-Low-Emission Combustion Technologies for Heat and Power Generation

The Combustion Technologies Group at Lawrence Berkeley National Laboratory has developed simple, low-cost, yet robust combustion technologies that may change the fundamental design concept of burners for boilers and furnaces, and injectors for gas turbine combustors.

The new technologies utilize lean premixed combustion and could bring about significant pollution reductions from commercial and industrial combustion processes and may also improve efficiency.

The technologies are spinoffs of two fundamental research projects:

1. An inner-ring burner insert for lean flame stabilization developed for NASA-sponsored reduced-gravity combustion experiments
2. A low-swirl burner developed for Department of Energy Basic Energy Sciences research on turbulent combustion.



LBNL low-NO_x burner showing 20-kW flame at 25 vol % excess air and 15-ppm NO_x (3 vol % O_2). Left: With ring stabilizer insert. Right: Without insert.

The ring stabilizer insert is a simple device. It is adaptable to many existing burner designs and enables them to maintain a steady ultralean premixed flame. The inner-ring insert is highly effective even under intense turbulence and produces complete combustion, but at the same time it lowers the emissions of oxides of nitrogen (NO_x) and carbon monoxide (CO). It has been tested in several interesting applications and produced very promising

results. In a laboratory study, when ring inserts were fitted to a multiport burner of a domestic forced air-furnace, the resulting efficiency was increased and emissions were well below current air quality standards. A leading U.S. water heater manufacturer has tested ring stabilizer inserts in a product prototype and scaled its design to operate up to 200 kW.

Discovered in 1991, low-swirl flame stabilization is a novel combustion concept that is counter to conventional high-swirl methods. Low-swirl burners can burn premixed ultralean fuel/oxidizer mixtures. Two versions of the low-swirl burner have been developed. One uses very small air jets to generate low-swirl; the other uses a patented vane-swirler designed especially to produce the divergent flow pattern needed to sustain the flame.

The feasibility of using the low-swirl concept for larger heating and power-generating systems has been demonstrated. A low-swirl burner capable of operating beyond 1 MW recently tested in a research furnace showed the same low emissions (less than 10-ppm NO_x and 20-ppm CO) and high combustion efficiency. For gas turbines, a concept prototype of a low-swirl injector was successfully tested in a gas turbine manufacturer's facility. These tests have established the potential of using low-swirl devices for power generation. Lawrence Berkeley National Laboratory is seeking industrial partners for commercialization.

Discovery and development of our combustion technologies are prime examples of the fruits of basic research. Basic understanding of the operating principles of these technologies was the key to the successful scaling of the burners from 15 kW to over 1 MW and to designing injectors for testing in gas turbines.

To support the development of this technology for other pressurized combustion systems, Lawrence Berkeley National Laboratory is building a laboratory-scale facility to study lean, premixed combustion with high inlet pressures and temperatures.

Glenn contact: Paul S. Greenberg, 216-433-3621, Paul.S.Greenberg@grc.nasa.gov
Author: Robert K. Cheng
Headquarters program office: OBPR
Programs/Projects: Microgravity Science