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Clean combustion technology

An experimental gas turbine simulator equipped with an ultralow-emissions combustion technology called low-swirl injector (LSI) has been tested successfully using pure hydrogen as a fuel.

LSI is already being hailed as a milestone that indicates a potential to help eliminate millions of tonnes of carbon dioxide and thousands of tonnes of NOx from power plants each year.

Developed by the US Department of Energy's (DOE) Lawrence Berkeley National Laboratory in California, the technology holds great promise for its near-zero emissions of nitrogen oxides, gases that are emitted during the combustion of fuels such as natural gas during the production of electricity. Nitrogen oxides, or NOx, are greenhouse gases as well as components of smog.

Reducing Emissions

The US DOE's Office of Electricity Delivery and Energy Reliability initially funded the development of the LSI for use in industrial gas turbines for on-site – distributed – electricity production.

The purpose of this research was to develop a natural gas-burning turbine using the LSI's ability to substantially reduce NOx emissions.

Lawrence Berkeley National Laboratory initially adapted the low-swirl injector technology to the Taurus70 gas turbine that produces about seven megawatts of electricity.

The laboratory is continuing the low-swirl injector development for renewable fuels available from landfills, carbon-neutral fuels from organic waste treatments, and for fuels from industrial processes such as petroleum refining.

DOE's Office of Fossil Energy is funding another project in which the LSI is being tested for its ability to burn syngas, a mixture of hydrogen and carbon monoxide, and hydrogen fuels in an advanced integrated gasification combined cycle (IGCC) plant called FutureGen.

FutureGen

This is an initiative to build the world's first integrated sequestration and hydrogen production research power plant. The US$1.5billion project is intended to create the world's first zero-emissions fossil fuel plant. When operational, the prototype will be the cleanest fossil fuel fired power plant in the world.

The initiative is a response to US President George Bush's directive to draw upon the best scientific research to address the issue of global climate change. The production of hydrogen will support his call to create a hydrogen economy and fuel pollution free vehicles; and the use of coal will help ensure America's energy security by developing technologies that utilise a plentiful domestic resource.

Additionally, other countries will be joining the USA to participate in the project.

The prototype plant will establish the technical and economic feasibility of producing electricity and hydrogen from coal (the lowest cost and most abundant domestic energy resource), while capturing and sequestering the carbon dioxide generated in the process.

The initiative will be a government/industry partnership to pursue an innovative 'showcase' project focused on the design, construction and operation of a technically cutting-edge power plant that is intended to eliminate environmental concerns associated with coal utilisation. This will be a 'living prototype' with future technology innovations incorporated into the design as needed.

The project is employing coal gasification technology integrated with combined cycle electricity generation and the sequestration of carbon dioxide emissions. The project is supported by the ongoing coal research programme, which will also be the principal source of technology for the prototype.

The project will require 10 years to complete and is led by the FutureGen Industrial Alliance, a non-profit industrial consortium representing the coal and power industries, with the project results being shared among all participants, and industry as a whole.

The LSI is one of several combustion technologies being evaluated for use in the 200-plusmegawatt utility-size hydrogen turbine that is a key component of the FutureGen plant.

How it works

The low swirl injector is a mechanically simple device with no moving parts that imparts a mild spin to the gaseous fuel and air mixture that causes the mixture to spread out.

The flame is stabilised within the spreading flow just beyond the exit of the burner (Fig.1). Not only is the flame stable, but it also burns at a lower temperature than that of conventional burners. The production of nitrogen oxides is highly temperature-dependent, and the lower temperature of the flame reduces emissions of nitrogen oxides to very low levels.

“The LSI principle defies conventional approaches,” says Cheng. “Combustion experts worldwide are just beginning to embrace this counter-intuitive idea. Principles from turbulent fluid mechanics, thermodynamics, and flame chemistry are all required to explain the science underlying this combustion phenomenon.”

Natural gas-burning turbines with the low-swirl injector emit an order of magnitude lower levels of NOx than conventional turbines.

Tests at Berkeley Lab and Solar Turbines showed that the burners with the LSI emit two parts per million of NOx (corrected to 15percent oxygen), more than five times less than conventional burners.

A more significant benefit of the LSI technology is its ability to burn a variety of different fuels from natural gas to hydrogen and the relative ease to incorporate it into current gas turbine design, so extensive redesign

of the turbine is not needed. The LSI is being designed as a drop-in component for gas-burning turbine power plants