Video System Shows Inside of Turbine Combustor

The Lenox FireSight monitoring system shows engineers exactly what happens after various fuels ignite inside turbine combustors.

Engineers at Siemens Westinghouse Power Corp. can now see, amid 857°C flames, exactly what happens after various fuels ignite inside turbine combustors.

A solid-state, high-temperature color video system withstands the flames of combustors within a fully instrumented atmospheric pressure combustor test facility in Casselberry, Florida, U.S.A., where the company initially screens new concepts (especially different fuel combinations) for reducing emissions like nitrogen oxide (NO_x).

The combustor test facility encloses a combustor section about 0.9 m long and 0.35 m in diameter. Injected at one end of the combustor, the fuel ignites in preheated air and moves through a transition area into a turbine section where instrumentation, installed where turbine blades are usually located, measures temperature, pressure and emissions.

The FireSight periscope reaches through the test rig and into the transition section. It can view the entire combustor, including the "basket" and the water-cooled measurement section.

The optical diagnosis system is a major improvement for obtaining more complete research data, according to Siemens Westinghouse engineers. When the test facility was first installed in 1993, engineers relied only on thermocouples and other instrumentation to measure hot gas temperatures, pressures and emissions.

After several years, however, researchers realized they needed another dimension for more complete knowledge of what was happening.

"Engineers had wonderful instrumentation and displays, but they couldn't see what was actually happening," said Richard Bunce, senior engineer, laboratories development, at the facility. "Instrumentation tells you how the fuel is burning, but they wanted to actually see the associated conditions."

Bunce contacted several vendors of periscopes that could operate in high temperatures. "Our older engineers remembered Lenox Instrument Co. in Trevose, Pennsylvania, U.S.A., which had supplied a successful high-pressure periscope for our combustor test rig in Concordville, Pennsylvania, in the late-1970s," Bunce said. "Lenox said it could adapt its advanced combustion viewing system, called FireSight, for our special application."

The test facility's FireSight system includes a water-cooled periscope that is 5 cm in diameter, which penetrates the test facility enclosure and the combustor's metal wall. The periscope is within a protective "wallbox," also water-cooled, which is the primary cooling shroud. An air-cooled quartz lens at the end of the periscope withstands 857°C temperatures within the transition section. The lens has a 90° field of view.

"We can look upstream at the entire area of the combustor section or turn the periscope around and look downstream at the instrumented section," said Bunce. "The viewing system makes diagnosing what's going on in the combustor dead easy in many cases. Before, we might have had to run a whole series of tests to try to isolate what was happening. Basically, we're testing unusual fuel combinations, simulating what we can actually run and judging what would be harmful to our turbines."

A series of achromatic relay lenses within the periscope carries images from the lens, which can operate if necessary in temperatures as high 1240°C, to a closed-circuit compact CCD color TV camera. An operator can actuate a motorized iris to adjust the amount of light reaching this camera.

Television images are transmitted to a 33 cm video monitor in the test facility's control room. The images are videotaped so that researchers can study them carefully, enlarging sections when desired.

The test facility operates at atmospheric pressure in order to screen concepts most cost efficiently, finding the best approaches and eliminating bad ones, before they are tested in the company's more-expensive high-pressure test rigs. The test facility is being used to screen a wide range of products. For instance, it has four instrumented feed passages for natural gas.

The instrumentation provides extensive information through a fast 56-channel data collection system in which four 50 MHz cards run in parallel for an effective throughput of 200 kHz.

"Many of the fuels are purely development projects," Bunce said. "We have basic designs but try to make changes to enhance them. We change the fuel/air splits, the primary and secondary zones. We're doing a lot of research at present on changing the pilot flame from a diffused flame to a catalytic flame to cut emissions, and we do passive control studies to minimize pressure fluctuations by various means."

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