Innovation

Taking the Heat

EPRI Examines Sensors That Can Withstand Harsh Environments in Gas Turbines

By Scott Sowers

EPRI is evaluating more rugged sensors to monitor natural gas turbines and help optimize operations of current and next-generation facilities.

Demand for natural-gas-fired generation is growing in North America, driven by low prices and ease of deployment. Some combined-cycle units are cycling more frequently or operating for more hours than they were designed to operate, challenging reliable operations. This has spurred efforts to enhance monitoring of the performance and condition of online units using sensors that measure various parameters—temperature, fuel flow, fuel pressure, air flow, air pressure, exhaust gas flow, fuel quality, and exhaust gas constituents.

A key consideration: Sensors must be able to withstand temperatures up to 1300°C—and even higher in the turbine's combustion zone—while providing accurate readings.

"Traditional electronic sensors fail quickly if exposed to high temperatures, so they are not usually viable options for the combustion zone of a gas turbine," said Principal Project Manager Susan Maley. "We need materials and designs that can sense temperature and pressure changes and other parameters at extreme temperatures for extended periods of time."

To protect today's sensors from high temperatures in gas turbines, they are often placed in "standoff tubes" located a certain distance away from areas being monitored, reducing measurement accuracy. The tubes also can lead to false readings as a result of condensation buildup.

One particularly important indicator of gas turbine operations is dynamic pressure. But at high temperatures and pressures, direct measurement is difficult. There are no accurate, commercially available sensors that can withstand combustion temperatures.

Operators often indirectly determine combustion temperature and other difficult-to-measure parameters by making calculations based on easier-to-measure parameters.

"We can back-calculate and make estimates, but these are not as accurate as direct measurements," said Maley.

Scanning the Sensor Technology Landscape

Researchers outlined measurement needs in the various parts of a natural gas turbine, including the compressor, combustion zone, and turbine. To meet these needs, they identified commercially available and emerging sensor technologies developed for the power generation industry and other industries such as aerospace. EPRI is tracking innovations at organizations such as the Propulsion Instrumentation Working Group, Air Force Research Laboratory, NASA, and the U.S. Department of Energy.

EPRI is looking at advances in wireless micro-sensors the size of a penny, sensors made of heat-tolerant ceramics, lasers that act as sensors, and fiber-optic sensors.

According to Maley, fiber optics are especially promising. "They sense and send signals using light transmission, rather than electronics, so viability in a turbine's hot zone is a worthwhile research and development effort," she said.

Correct turbine blade operation is vital, and EPRI is evaluating sensors that measure blade dynamics, which include vibration, strain, clearances, tip deflection, and timing.

“The blades are designed to have some flex. But under certain conditions, their resonant frequencies can become excited, and the blades can break off,” said EPRI Senior Technical Leader Bobby Noble. “This can cause many other blades to fail and lead to a ‘corn-cobbing’ effect on the turbine’s compressor section, which can cost millions of dollars to fix.”

The next step is field evaluations of promising technologies. EPRI also will continue evaluating new sensors in collaboration with the Georgia Institute of Technology. A report on key findings is expected in 2017.

“With better sensors, we can positively impact turbine performance, efficiency, and reliability,” said Maley. “We hope to identify a few options that can benefit the industry and the public through more reliable and less expensive generation of electricity.”

“Just like with personal computers, sensor technology is making the impossible possible,” said Noble. “What once was thought to be too hot or too hard to get to is now possible.”

Key EPRI Technical Experts

Susan Maley, Bobby Noble