In Development

Turning Up the Heat

Ohio Facility to Test Advanced Coal Plant Components at 1400°F

By Chris Warren

Between 1920 and 1960, the average thermal efficiency of U.S. coal plants increased from about 5% to more than 30%. This impressive gain was driven largely by an increase in plant operating temperatures from about 600°F to 1100°F in the 1960s.

Since the 1960s, however, such gains have leveled off. “Today’s coal plants are approaching the fundamental limit of the iron-based steel used in turbines, boilers, pipes, and other components,” said Jeffrey Phillips, a senior program manager at EPRI. “Once the temperature gets above 1100°F, the steel loses strength. If we want higher efficiencies, we have to use different materials.”

Improving efficiency through more rugged materials results in burning less coal and emitting less CO_2 to produce a given amount of electricity. According to Phillips, operating coal plants at 1400°F would result in a 20% emissions reduction and a 24% increase in thermal efficiency relative to the current U.S. coal fleet average. Increasing a 500-megawatt coal plant’s thermal efficiency by 24% could potentially yield a savings of $10–15 million in annual fuel costs.

Testing Nickel Alloys in the Field

For 15 years, EPRI has collaborated with utilities, government agencies, and equipment manufacturers to test the strength of plant components made of nickel alloys. “These laboratory tests tell us that we have a material that can withstand 1400°F,” said John Shingledecker, program manager of EPRI’s fossil materials research. “Now we need to prove these materials in an operating power plant.”

Enter the Advanced Plant Component Test Facility, slated for Youngstown, Ohio. Funded by the U.S. Department of Energy (DOE) and the Ohio Coal Development Office through grants to Energy Industries of Ohio, the public-private initiative plans to retrofit a coal-fired heating facility with nickel alloy components—such as a 7-megawatt steam turbine—and then operate it at 1400°F for two years, starting in September 2018. The project also is funded by EPRI and equipment manufacturers Babcock & Wilcox Company and GE.

As the project’s technical lead, EPRI is coordinating participants, advising construction company AECOM as it executes facility engineering and design, and issuing progress reports. Babcock & Wilcox is designing the superheater that will produce steam at 1400°F, while GE will design and build the steam turbine. Energy Industries of Ohio is providing project management and coordinating financial, contractual, and administrative matters. DOE is helping to guide the project by setting technical goals. Oak Ridge National Laboratory is supporting materials selection.

For testing flexibility, the coal-fired plant will not connect to the grid and generate electricity, as the facility did in the past. One priority is to examine how plant cycling affects the nickel alloy. “Fossil power plants are doing a lot of cycling today to accommodate variable wind and solar generation,” said Phillips. “We will simulate starting and shutting down the plant 2,000 times by putting the equipment through 2,000 thermal cycles.”

After the plant is operated for at least 8,000 hours, key sections will be sliced into pieces and examined under microscopes for cracks, chemical changes, and other signs of deterioration.

Phillips expects that a successful demonstration of the nickel alloy would lead to a more ambitious project. “We could have a 500-megawatt plant tied to the grid and designed to operate for 30 years,” he said.

The more efficient plants built with these new materials could help utilities meet the New Source Performance Standards. “Plants with higher efficiencies burn less coal to produce the same amount of electricity—and that means lower CO_2 emissions,” said Phillips. “Using today’s coal plant technology, you have to capture and store about 30% of the CO_2 to help new plants meet those standards. If you use higher temperatures and efficiencies, you could only have to capture about 15%.” In addition, retrofitting this technology into existing coal power plants could help states meet the CO_2 emission reductions required by the Clean Power Plan.

Key EPRI Technical Experts

Jeffrey Phillips