GEORGIA TECH RESEARCH

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EXTENDING THE LIFE OF AGING PLANTS: RESEARCH PREDICTS GROWTH OF CRACKS IN PIPING AND CRITICAL COMPONENTS

In June of 1985, a massive steam pipe ruptured at an electric powerplant, killing or injuring a dozen workers. A similar failure occurred later at another plant, but without casualties. As many of America's plant facilities approach the end of their planned operating lives, their operators have become more concerned about such catastrophic breakdowns.

At the Georgia Institute of Technology, researchers have developed techniques for predicting how long such high temperature components can safely remain in service. Their work could save electric utilities and other plant operators billions of dollars by extending the lives of these aging facilities, and reducing unscheduled outages due to mechanical failure in equipment.

High-temperature components age because of stresses imposed by operating pressures and by exposure to elevated temperature over a prolonged period of time. These stresses initiate creep cracks at weak points in the metal, and cause both fabrication-induced and service-initiated defects to spread.

"Cracks can grow internally until one day there is a major rupture," said Dr. Ashok Saxena, professor of materials engineering at Georgia Tech. "We are trying to prevent such failures by establishing appropriate inspection intervals in areas prone to cracks."

Components such as steam pipes, turbine rotors, generator components and boiler parts are susceptible to varying degrees of damage, depending on the materials from which they were made and the conditions under which they have been operated.

Electrical generation and petrochemical plants are most affected, though any high-temperature component can suffer damage from the stresses.

"We are studying how fast these defects grow in various materials under various conditions of operation, and get to a critical size where fracture can occur," Saxena added. "That becomes the basis for establishing inspection intervals and determines the crack size you should be inspecting for."

In most cases, inspections are costly and can be performed only when the plant is temporarily out of service. Plant operators, therefore, must set inspection intervals frequent enough to locate defects before they become critical.

When many of America's largest industrial plants were built during the 1950s and 1960s, designers expected the facilities to have operating lives of 30-40 years.

"By 1990, about 70 percent of the reserve power in the country will be generated by fossil-powered units that are more than 30 years old," Saxena noted. "The investment required to replace these units, which were originally designed for a 30-year life, is on the order of several billion dollars."

But metallurgical science now has advanced to the point that much better predictions can be made of how long components can safely operate.

"What the industry would like to do is get another 20 to 30 years of life from these existing plants by changing some of the critical components if needed, or by mandating more stringent inspection requirements to be sure the equipment can be used safely," he added.

Based on current inspection data and how it has been operated in the past, the Tech researchers can predict how much longer a component can safety be kept in service. That prediction is based on extensive testing of materials done at Georgia Tech and other institutions.

The work also forms the basis for a personal computer program called "PCPIPE" that can be used by utilities to do their own lifetime predictions. After requesting data on piping material, piping sizes and operating history, the program predicts how many more hours the piping can safely be used.

"You can make a more meaningful decision on whether to run, retire or repair the component," said Saxena. A dozen U.S. utilities now use the program.

Predicting the lifetime of high temperature components relies on study of two main properties: the material's inherent resistance to fast fracture, and the rate at which defects grow under varying combination of stress and temperature. The process assumes that hidden cracks exist in critical components, and examines how long it would take those flaws to reach critical levels.

Working with Dr. David McDowell in Tech's School of Mechanical Engineering, Saxena now directs three separate projects to assess high temperature failure problems. Totaling nearly $850,000, they are sponsored by the Electric Power Research Institute (EPRI), and by the U.S. Department of Energy.