

Tennessee Valley Authority Kingston, Tennessee

Extended life of induced draft fan blades from 5 - 8 months to over 30 months

The Tennessee Valley Authority's (TVA) Kingston Power Plant was completed in 1955 and is one of 11 coal-fired power plants owned and operated by the TVA. The plant is located west of Knoxville, Tennessee at the junction of the Emory and Clinch Rivers.

For more than a decade after its completion, Kingston was the largest coal-fired power plant in the world. The plant currently burns low sulfur coal from central Appalachia.

The Kingston plant operates nine coal-fired boilers and produces approximately 10 billion kilowatt-hours of electricity each year, supplying more than 700,000 homes. In order to meet demand, the plant burns about 14,000 tons of coal daily. All nine boilers use a blend of low-sulfur coal to decrease SO₂ emissions. In order to reduce NO_x, boiler Units 1-4 and Unit 9 use combustion controls and boiler optimization, while Units 5-8 utilize low NO_x burners.



TVA's Kingston Power Plant

In 1977, electrostatic precipitators were added to the boiler units. Due to space and financial limitations, the induced draft (ID) fans for Units 5-9 were left upstream of the electrostatic precipitators and mechanical fly ash collector, while the ID fans for Units 1-4 were moved downstream of the precipitators.

Within six months after the precipitators were installed, maintenance personnel discovered that the ID fans for Units 5-9 were being severely eroded by fly ash. The fans were experiencing high dust loads of approximately 3.6 grams/acfm. At an average run time of 12-14 months, the steel fan blades, supporting hardware, and center hub had to be repaired or replaced. Eventually, erosion progressed to the point where several fan blades wore completely through, resulting in a fan failure and causing the fan to be lifted off its concrete foundation.

Preventative Maintenance

As part of an ongoing preventative maintenance program, TVA plant engineers take weekly vibration readings on all ID fans. Although vibration is a good general indicator of erosive wear, readings do not always follow a reliable linear trend. In two separate cases, fan vibration levels were within acceptable limits, but erosion had already completely destroyed the fan.

According to Dan Cowser, Manager of Outages & Capital Projects at the Kingston plant, "Fan erosion has been one of our highest maintenance cost items, costing the plant over half a million dollars annually in parts and labor alone. More than once, we have evaluated moving the ID fans in order to reduce or eliminate related fly ash erosion. However, it would take about 20 years for the company to recoup the costs. The project would entail a major fan redesign and a tremendous increase in fan motor horsepower to maintain required performance levels."

Fan Blade Testing

Cowser, who began working at the Kingston plant in 1997, noted that the ID fans were running 12 to 14 months between maintenance repairs. In 1999, the plant installed new sootblowers and Units 5-9 ID fan life shortened to five to eight months. Cowser commented, "It was obvious that fan wear increased due to the pumping of more erosive fly ash through the system."

Boiler units are not taken off line for fan repairs, however, a significant derating is needed each time a fan requires re-blading.

Due to the increasing costs associated with shorter fan run times and the need to operate at full capacity during periods of peak demand, Kingston plant personnel enlisted TVA's Energy Research & Technology Applications (ER&TA) group and the Electric Power Research Institute (EPRI) for assistance.



Unprotected steel fan blades showed severe erosive wear after three months of service

ER&TA supports TVA's plant and transmission system operators with the research and development of new technologies.

EPRI, a nonprofit organization that provides science and technology based solutions to global energy customers, conducted testing in cooperation with ER&TA, to determine which protective materials could endure the severe erosion experienced by Kingston's Units 5-9 ID fans.

Donna Dearmon, Project Manager for EPRI's Instrumentation & Control Center conducted the search for suppliers of wear resistant materials and coordinated the day-to-day activities with TVA's staff.

The project was initiated in the fall of 2001. The study examined 16 wear protected fan blades from six commercial suppliers. Tested materials included chrome carbide weld overlay, tungsten carbide manual flame spray with a furnace fuse, two types of tungsten carbide high velocity oxy-fuel (HVOF), tungsten carbide plasma spray, and Kennametal Conforma Clad® infiltration brazed tungsten carbide cladding.



Tungsten carbide cladding measurement taken by TVA ER&TA group

Fan blades were tested over a 69-day period on Kingston's Unit 9 ID fan. The fan was a double inlet, single exhaust, 400,000 CFM Westinghouse model 16MVID, with forward curved fan blades. The fan was comprised of 120 blades with a shaft speed of 593 RPM.

The original fan blades weighed 34 pounds each. Because Kennametal Conforma Clad's infiltration brazed tungsten carbide material added five pounds to each fan blade, a new blade was designed. The blade's wear pad was removed and a full penetration weld was used instead of a fillet weld to reduce overall weight and improve strength.

Wear protected blades were distributed throughout the fan. In order to facilitate balancing, the heavier infiltration brazed tungsten carbide clad blades were located 180° apart. Because material wear rates were unknown, test organizers carefully distributed the blades to ensure that erosion-induced weight change would not require fan rebalancing.

At the end of the 69-day test all blades, except those protected with infiltration brazed tungsten carbide cladding, were removed. The blades protected with chrome carbide weld overlay and tungsten carbide HVOF were removed due to complete coating wear-through. The blades protected

with chrome carbide weld overlay experienced a material loss of 0.150", suffered from a crack at the center junction plate, and experienced extreme wear at the leading edge. Measurements taken from the Kennametal Conforma Clad® blades showed a material loss of less than 0.010" at the leading edge.

"Kennametal Conforma Clad's brazed tungsten carbide material displays superior erosion resistance."

- EPRI CS6068, Project 1649-4

These results were consistent with findings from a 1988 TVA/EPRI study (EPRI CS6068, Project 1649- 4), which also tested the effects of fly ash erosion in coal-fired power plants. A rainbow wheel carrying more than 10 different types of wear protection shields was installed in a highly erosive boiler environment. At the completion of the test, the Westinghouse Research and Development Center, who prepared the study, reported in the final EPRI report that "Kennametal Conforma Clad's brazed tungsten carbide material displays superior erosion resistance."

New Wear-Protected Blades Installed

Based on the test results, Kingston began retrofitting Units 5-9 ID fans with blades from Kennametal Conforma Clad. The first blades were installed in October 2002, in Unit 8B's ID fan. After seven months



Kennametal Conforma Clad® blades on fan Unit 8B showed 0.014" after seven months run time

of run time, the tungsten carbide clad blades showed a material loss of 0.014" or less, primarily at the leading edge. Based on the applied tungsten carbide cladding thickness, the blades are expected to last more than 30 months, four times the life of unprotected fan blades.

The test data shows that the densely-packed tungsten carbide cladding wears at a uniform and predictable rate. High bond strengths, in excess of 70,000 psi, result in a protective barrier that resists chips, cracks and flakes.

The results of the collaborative testing are promising. The limited amount of material wear on Kingston's Unit 8B fan after seven months of run time further substantiated the test results. EPRI indicated that the final report is in its draft stage.

For Further Information

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