Reactive Cap Shows Potential to Remediate Coal Tar

From the mid-1800s to the mid-1900s—before the nation's extensive network of natural gas pipelines had been established—thousands of local manufactured gas plants (MGPs) produced synthetic natural gas from coal for heating, cooking, and lighting in many parts of the United States. Most of the sites closed during the 1960s, but many of the closures did not address an environmental hazard left behind by the plants—the presence of large amounts of coal tar. Coal tar is composed of hundreds of compounds, some of which are toxic to humans, animals, and plants. Many MGP facilities were located adjacent to rivers and streams, and because coal tar is denser than water, it is often present in river sediments and is challenging to clean up.

A limited number of remediations are available to reduce the exposure potential for humans as well as the risks to the environment. Sediment removal—dredging—has been a commonly used remedy, but it has had mixed results in achieving cleanup goals. One option that has shown promise as an alternative to sediment removal is reactive capping—covering the tainted river bed with a permeable mat of chemically reactive material that can adsorb coal tar residues.

Field Testing

In 2006, EPRI began planning a field-scale demonstration of three types of reactive caps to control and/or contain coal tar–impacted sediments at a former MGP site adjacent to the Hudson River in New York state. Field work began in 2009, and the test was concluded in January 2011. The project was sponsored by nine EPRI members and hosted by Central Hudson Gas & Electric Corporation at their Poughkeepsie site.

The caps were assembled using Tensar International's Triton® marine mattresses filled with three different types of material:

- Type 1—mattresses filled with 6 inches (15.2 cm) of armor stone, underlain by an organoclay-filled CETCO Reactive Core Mat® (RCM) and geogrid
- Type 2—mattresses filled with 3 inches (7.6 cm) of armor stone and 3 inches (7.6 cm) of sand (wrapped in geotextile)
- Type 3—mattresses filled with 3 inches (7.6 cm) of armor stone and 3 inches (7.6 cm) of bulk organoclay/sand (wrapped in geotextile), underlain by an organoclay-filled RCM and geogrid

Organoclay is a manufactured product in which clay material is mixed with other chemicals to enhance its adsorptive capacity. Laboratory testing using site-specific coal tar was conducted to identify the organoclay best suited for the site. For each cap type,

Sorbent-filled marine mattresses are lowered into the Hudson River to test their effectiveness in cleaning up coal tar residues.

25 mattresses measuring 6.5 feet (2 m) by 20 feet (6.1 m) were ganged together and lowered to the river bottom by crane. Site characteristics considered during the study design included strong river currents, relatively deep sediments (approximately 50–60 feet [15.2–18.3 m] below the water surface), and the presence of underwater infrastructure, such as natural gas pipelines and high-voltage electric transmission lines. The caps were left in place for 18 months.

Positive Results

Divers performed physical inspections throughout the testing period and extracted samples, which were periodically analyzed. At the end of the testing period, the caps were removed and further analyzed for effectiveness. Following is a summary of study conclusions:

- The Type 1 caps had the highest level of success. These mats had approximately twice the adsorption capacity of a 5:1 mixture of sand and bulk organoclay and approximately three times the adsorption capacity of sand.
- Organoclay-filled RCMs retained significant adsorption capacity and permeability 18 months after initial placement—performance comparable to that of unused sorbents
- The effective life of organoclay-filled RCMs depends on the mass of coal tar in the sediments and the mechanisms and rate of transport from the sediments to the overlying water.

The results of this study demonstrate that a reactive capping system may provide utility site managers a viable alternative to sediment dredging, which may not be feasible in locations where contamination is at great depths and strong water currents are present. The choice of material to fill the caps will depend on the characteristics of each site. Detailed findings are presented in the final technical update report (EPRI report 1022757).

For more information, contact Jeff Clock, jclock@epri.com, 845.608.0642.

Powder Metallurgy Improves Fabrication of Large, Complex Components

Valve bodies, pump housings, piping elbows, and many other large and complex power plant components are commonly fabricated using metal casting processes similar to those first applied more than 50 years ago. After casting, extensive machining is typically required to prepare components for service duty, and once installed, components are often difficult to inspect because of a complex cast microstructure.

EPRI's Technology Innovation program is leading collaborative development of powder metallurgy fabrication as an alternative to casting. This breakthrough technology promises to significantly decrease rework and improve inspectability, reducing both costs and risks for nuclear power producers. It could also lead to components with characteristics such as enhanced erosion resistance that today can be achieved only by using coatings or other post-manufacturing treatments.

Powder metallurgy fabrication methods were initially developed for aerospace and other specialty components, which are commonly much smaller than those used in power plants. The process begins with component design, alloy specification, and mold construction. A mold is loaded with metallic powder of the desired composition, degassed under vacuum, and sealed. High temperatures and high pressures consolidate the powder into a solid with homogeneous microstructure.

Scaling Up for Power Plants

In 2009, EPRI initiated exploratory research to apply powder metallurgy methods in fabricating large, complex power plant components. Working with Carpenter Technology and two valve manufacturers, EPRI demonstrated the feasibility of using an austenitic (316L) stainless steel powder to produce a 12-inch- (30.5-cm-) diameter valve body in "near net shape." The component incorporated intricate features, required no finish machining, and offered exceptional toughness, a 15% improvement in mechanical performance, and superior inspectability relative to conventional cast stainless steel components.

Valve bodies have now been produced from a broad cross section of materials used in nuclear, conventional coal, and ultra-supercritical coal plant applications, including 316L stainless steel, a creep-strength-enhanced ferritic steel (Grade 91), and a nickel-based alloy (Inconel 625). Detailed testing is under way to verify inspectability and weldability, and to generate data required to support an American Society of Mechanical Engineers (ASME) code case permitting these processes to be used for fabricating large pressure-retaining components.

EPRI expects a code package for 316L stainless steel to be submitted to ASME in 2011, with other alloys to follow in 2012. Pending process qualification, an in-plant testing and demonstration program for large-scale powder metallurgy valves is scheduled for 2013, and commercial manufacturing could begin that same year. For both nuclear and fossil plants, the technology has true breakthrough potential for replacement components and new construction. Primary advantages include:

- ***Efficiency.*** "Near-net-shape" components reduce materials waste and minimize machining and cleanup. Improved production efficiency reduces manufacturing and delivery lead times and costs.
- ***Inspectability and weldability.*** Cast components may contain microstructural irregularities that make nondestructive inspection difficult. Powder metallurgy produces a very uniform, homogeneous microstructure that is much more amenable to inspection for both defects and sizing. The microstructural properties also enhance weldability.
- ***Optimization.*** Powder metallurgy allows materials' composition to be specified and optimized component by component, reducing waste and facilitating the use of new alloys.

Follow-On Research

EPRI is exploring powder metallurgy's advantages for precisely controlling materials composition during fabrication to achieve desired functional characteristics, such as increased erosion resistance at the surface of a valve, fan blade, or turbine blade. A feasibility demonstration is focusing on valves made with 316L stainless steel that incorporate materials to reduce erosion, wear, and galling at the surface, along the seat/hardfacing region.

For more information, contact David Gandy, davgandy@epri.com, 704.595.2695; Greg Frederick, gfrederi@epri.com, 704.595.2571; or John Shingledecker, jshingledecker@epri.com, 704.595.2619.