THIS MONTH: PIPELINE CORROSION

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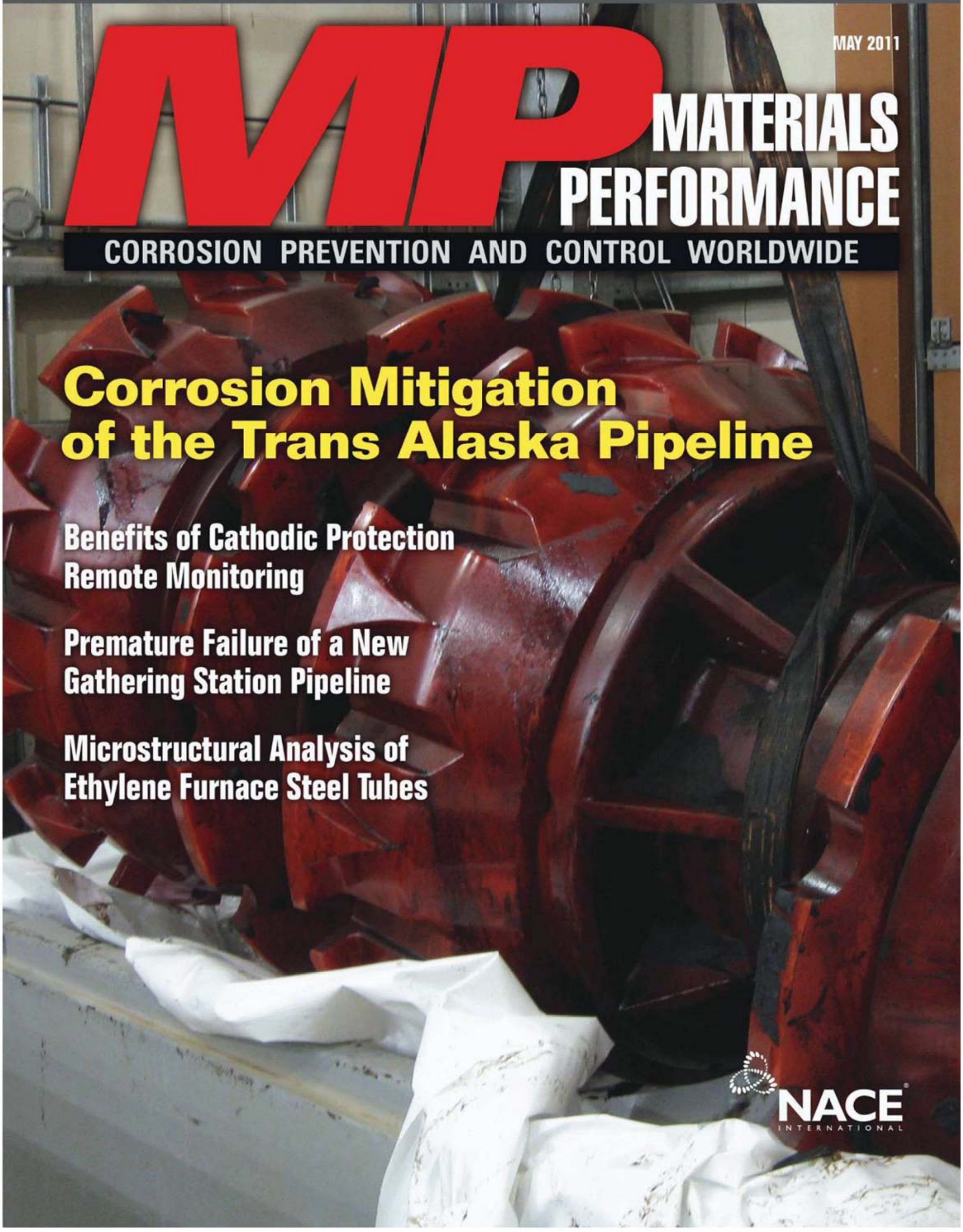

Corrosion Mitigation of the Trans Alaska Pipeline

Benefits of Cathodic Protection Remote Monitoring

Premature Failure of a New Gathering Station Pipeline

Microstructural Analysis of Ethylene Furnace Steel Tubes

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High-density infrared cladding system rapidly coats large surface areas

A high-density infrared (HDIR) plasma arc lamp melts a nickel-based alloy material onto a substrate. Photo courtesy of MesoCoat, Inc.

A novel fusion cladding system that applies corrosion- and wear-resistant alloys (CRAs and WRAs) to large surface areas is being developed and commercialized by MesoCoat, Inc. (Euclid, Ohio), a venture-backed nanotechnology materials science company. Based on a high-density infrared surface modification technology developed over the past decade by Oak Ridge National Laboratory (ORNL), a multi-program science and technology laboratory managed for the U.S. Department of Energy (DOE) by UT-Battelle, LLC, and licensed exclusively to MesoCoat in 2009, the cladding system uses a high-density infrared (HDIR) plasma arc lamp to bond a uniform layer of nanocomposite material to the metal substrate.

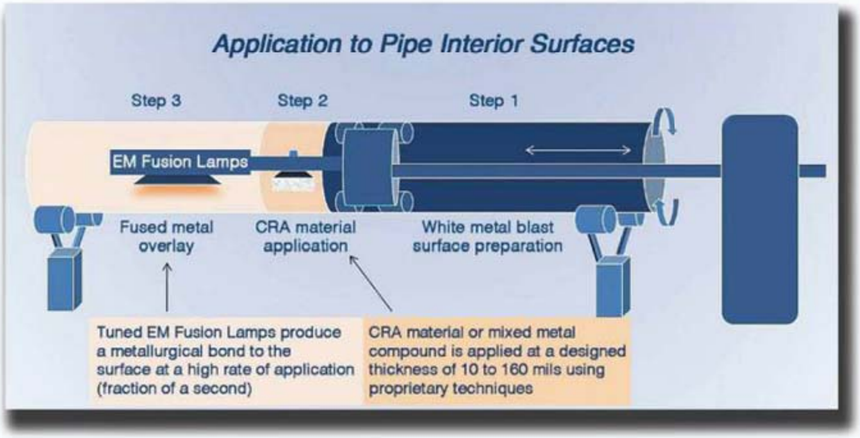
The application process utilizes an approach similar to current cladding processes, but the HDIR plasma arc lamp replaces lasers or welding arcs as the heat source. The steel surface to be clad is prepared using surface cleaning methods. Then an atomized metal slurry is deposited by a spray nozzle onto the substrate. The application process is comparable to applying an epoxy or other coating to a surface.

As the HDIR lamp passes over the substrate, it melts the powders in the slurry almost instantaneously, causing them to fuse to the substrate and form a protective coating. The high quench rate ensures a very quick metallurgical bond with little or no damage to the metal substrate. This process can be used to apply an assortment of metals, alloys, ceramics, metallic glass, polymers, aluminum-zinc, or fusion-bonded epoxy coatings on a wide variety of steel structures such as surfaces of internal and external pipe used in the oil and gas and oil sands industry, steel reinforcing bars for concrete, tubes, plates, sheets, bridge girders, heat exchangers, reactor vessels, and ship decks.

The HDIR plasma arc lamp, one of the key components of the process, creates infrared thermal conditions that can reach temperatures in excess of 3,000 °C, says Andrew Sherman, founder and CEO of MesoCoat. By incorporating a new design to focus the plasma arc energy, MesoCoat was able to enhance the technology so it melts stainless steel (SS), CRAs, WRAs, and ceramic-metallic powder coatings in a fraction of a second. "If you've ever started a fire with a piece of paper using a magnifying glass, you've got the basics of the process," explains Sherman. Because of the way the process works, with low heat input to the substrate, the focused plasma arc method can fuse and metallurgically bond coatings and substrates without convective mixing, which means the substrate metal temperature doesn't exceed its melting point, "stirring" of the substrate surface is minimized, and the substrate's structural integrity is retained. The heating rate with the HDIR plasma arc lamp is 1,000 to 3,000 W/cm^2, the dilution rate is <1% as little as 20 µm from the surface/cladding interface, and the bond strength is >75,000 psi (517 MPa), Sherman adds.

The size and shape of the lamp enables the application of smooth, wide tracks of cladding (200- to 300-mm wide) that cool quickly. This allows rapid cladding treatment rates as well as enhanced flow efficiency inside a pipe. Sherman notes that a 12-m length of 14-in (356-mm) diameter pipe can be clad in 2 h or less. "The ability to produce seamless and defect-free clad pipe at a very high rate was certainly a major technology gap. It was simply not possible to provide metallurgically clad seamless pipe in the quantities needed by industry. The speed of this process would ensure that metal cladding can match the line speed of steel mills, and reduce lead times for clad pipes and tubes by 75 to 80%," he says.

Originally, the HDIR plasma arc lamp was used by NASA to simulate the extreme conditions in a high-speed turbine engine's combustor as well as the heat fluxes that occur when spacecraft reenter the Earth's atmosphere, Sherman says. Although MesoCoat has its own laboratory-scale HDIR equipment, and will soon have production scale equipment, a



The diagram outlines the HDIR plasma arc lamp cladding process for a pipe interior. Image courtesy of MesoCoat, Inc.

Space Act Agreement with NASA gives the company access to operate the high-powered, 200-kW HDIR lamp at NASA's Glenn Research Center in order to demonstrate and validate its metal and ceramic coating processing technologies for cladding trials with several major oil and gas companies.

Sherman notes that his company is also developing nanocomposite cladding materials for use with this fusion cladding process—Type 316L (UNS S31603), Type 317L (UNS S31703), and Type 904L (UNS N08904) SS; nickel-based Alloy 625 (UNS N06625) and Alloy 825 (UNS N08825); and nickel-copper alloy Monel† 400 (UNS N04400)—that meet accepted compositions and specifications outlined by API and Det Norske Veritas (DNV) standards. The standards have fairly wide ranges on compositions, he says, and alloys can be tailored to achieve dramatically different performances depending on the modifications within allowable limits and the resulting microstructures. Atomized metals, along with inert nanoparticles such as nucleating agents and grain refiners, are microalloyed to refine and control microstructures and improve thermal response, flow response, and corrosion performance. Once the material is fused to the substrate, it conforms to current material specifications, Sherman adds.

The company has received several U.S. Department of Energy (DOE) Small Business Innovation Research (SBIR) awards in fiscal year 2009 and 2010 to further develop the cladding process for various end uses, including oil and energy applications, metal processing, and advanced heat exchangers within thermoelectric systems; and signed a Cooperation Agreement with Petrobras (Rio de Janeiro, Brazil) in January 2011 to develop and qualify its HDIR plasma arc lamp cladding process for applying CRAs to internal and external pipe surfaces. The process is not commercially available at this time.

More recently, MesoCoat announced a collaboration with the University of Akron (UA) (Akron, Ohio), financed through a $2 million Ohio Third Frontier Award, that will focus on development, testing, and risk reduction of advanced inorganic coatings, including high-performance polymer, metallic, and ceramic nanocomposite coatings, in a new joint-use facility to be built at UA that will house the HDIR plasma arc lamp cladding technology. The metal cladding and powder coating materials developed by MesoCoat will be tested for life extension and cost reduction projections by a UA polymer engineering student research team led by Mark Soucek, a UA polymer engineering professor.

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