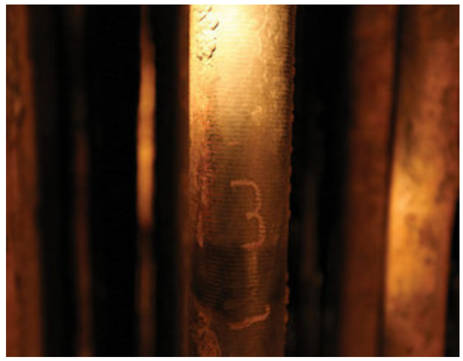
Laser Cladding Advancements for Pressurized Boiler Components

Energy plants that use wood, construction debris and municipal solid waste can benefit from recent advances in laser metal deposition.

By Scott Poeppel | December 28, 2017





Pictured is a leading super heater tube from a test sample inspection. Boiler inspection was performed after approximately 14 months of operation. No shielding was installed on test samples. This image was taken after a water wash cleaning of the sup
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In the power generation industry, one of the most inhospitable operational environments occurs within the boilers operating at waste-to-energy (WTE) facilities. There are many categories, but the most common WTE facilities use a fuel source that ranges from wood or construction debris to municipal solid waste (MSW). Within these boilers, pressurized boiler components are subjected to high temperatures (1,600 to 2000 degrees Fahrenheit), high pressures (850 to 1,200 psig) and fuel that is both highly corrosive and erosive. The principle corrosive component is the high-chlorine flue gas created by incinerating the fuel source. Erosion is accelerated due to fly ash impingement, and cleaning cycles performed by soot blowers within the operational boiler. To compound this corrosion/erosion effect, as the fly ash debris builds up onto the boiler components, it begins to block flu gas pathways. This buildup reduces the heat transfer across the boiler components, resulting in thermal hot spots within the boiler. As more surface area of the flu gas pathway is choked off, the remaining open pathways experience high-velocity fly ash impingement to nearby boiler component surfaces. Pressure components such as super heater tubes, super heater platens and water wall panels are all subjected to this hostile environment, and must be replaced at regular intervals, at a significant cost to the energy producer.

Mitigation of Wear, Corrosion
In an effort to extend component life and reduce replacement costs, the WTE industry has turned to overlaying their boiler pressure components with materials that help minimize wear rates associated with corrosion and erosion. Currently, the typical MSW boiler will process 1 percent (by weight) of chlorine through the boiler. In some of the larger facilities, this can equal 1,000 tons of chlorine burned per month. The most common overlaying alloy used in the power generation industry is Inconel 625. Known as a nickel-based alloy due to its high nickel content, Inconel 625 also contains, elevated amounts of chromium and molybdenum, providing a high level of pitting and crevice corrosion resistance caused by chloride contamination. This alloy can be found in generating plants that include coal-fired, biomass, nuclear and WTE. In this industry, a typical overlay thickness is 0.070- to 0.100-inch thick for pressurized boiler components.

A common term for overlaying a metal component with a dissimilar alloy is known as cladding. The advantages of cladding are principally economic. The cost of using a less expensive alloy, (common example: SA213-T22) as the primary boiler component material, and cladding a layer of Inconel 625 over the surface, will cost much less than buying the entire component made from a solid piece of Inconel 625. Another advantage of using an overlay is that material properties might be such that complete components are impossible to fabricate, making cladding the only choice.

Laser Overlay Development
In February of 2011, American Cladding Technologies began working with a North American WTE power producer in an effort to create and apply a laser coating that would outperform Inconel 625 on pressurized boiler components. Though Inconel 625 was shown to be effective, it still fell short of component lifetime performance goals. Working with ACT, the power producer determined that laser cladding offered benefits that could not be realized with the more traditional methods of applying weld overlays. The development process was a collaborative effort between the WTE power producer's boiler reliability engineers, ACT laser process engineers, a producer of metal powdered alloys, and various university material testing facilities. Once a powdered alloy composition was selected, testing trials began with 10-foot, individual segments installed in various boiler pathways, on primary and secondary super heater pendants. Periodic boiler inspections were performed on the test samples to track performance. The project goals were to extend boiler pressure component lifetime by a minimum of two times, eliminate or reduce the use of shielding on super heater tubes, and optimize the laser cladding process to be cost competitive with existing overlay methods.

By the end of 2011, the performance data on the test samples showed results encouraging enough to warrant moving ahead with continued laser metal deposition of super heater tubes. ACT accepted its first purchase order to laser clad a set of 2.5"Ø, SA213-T22 super heater tubes for delivery in January 2012. As of November, more than 38 WTE boilers across the U.S. are now operating with coatings developed by ACT. The principle components that show the largest benefit include primary/secondary super-heater tubes and platens. Another boiler component benefiting from this process is the soot blower lance. With encouraging performance data, ACT has now begun testing in both the biomass and pulp and paper industries.

Findings, Results
In order to maintain customer confidentiality, ACT will not release or discuss specific values regarding the realized cost savings, power plant operating values or any other data that might be considered sensitive to our customers. However, a general overview of the performance results is as follows:

Improved thermal efficiencies compared to the preexisting Inconel overlays. a) Elimination or reduction of shielding has reduced ash buildup in the low-flow areas between the shield and tube face, and therefore improved heat transfer. b) Reduced heat input of the laser cladding process results in a very low dilution of the cladding material. This allows for a reduced coating thickness which aids in thermal efficiency.

Reduced costs. a) Reduced or eliminated costs associated with shielding procurement and installation. Shielding the lead tubes for most super heaters has been eliminated. b) Reduced the need for (and costs of) unplanned outages by extending boiler component life. c) Boiler life has more than doubled for most facilities. Prior to coating development, the typical Inconel-coated super heater lifespan was 16 to 24 months. At the time of this writing, some super heater components have now been in service for over five years.

Other advantages of laser hard-facing over preexisting Inconel overlays. a) Reduced fly ash erosion due to the increased wear resistance of the coating. The typical laser applied overlay is 66 to 70 Rc and very wear resistant. b) By eliminating or reducing super heater tube shielding, hot spot formation has been reduced, thereby reducing localized failure points. c) Less debris buildup onto super heater tubing. Soot blower cleaning cycles have been reduced. Some facilities have reported a 79 percent reduction in cleaning cycle frequency. d) For continuous inline soot blower lances, component life of the lance has been extended by up to six times their preexisting lifespan due to the laser coating.

Production cost per linear foot of the laser hard-facing can be equal to or less than the linear foot cost of traditional Inconel 625 overlays. Cost reductions of 40 percent have been realized. These cost swings are largely dependent on total production quantity; required coating thickness, which is significantly less than typical Inconel wire overlays and therefore leads to reduced filler material costs and cladding cycle times; laser deposition rates, which continue to increase as the development effort continues; and the geographic region within the U.S., as overlaying costs vary per region.

In summary, due to the low heat input and rapid solidification of the weld pool, the microstructure of the laser overlay is typically superior to traditional overlay methods, and coating thickness can be reduced while maintaining full material properties.
All three project goals were achieved through the laser clad development. SH life has doubled or tripled, most, if not all, tube shielding has been removed, and the overall cost of application is now competitive with the traditional, wire-fed Inconel overlay methods.

Author: Scott Poeppel
Vice President, American Cladding Technologies
860-784-1962
spoeppel@americancladding.com

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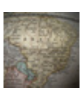
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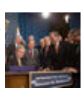
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