Figure 5. Fouled pre-heater coils.

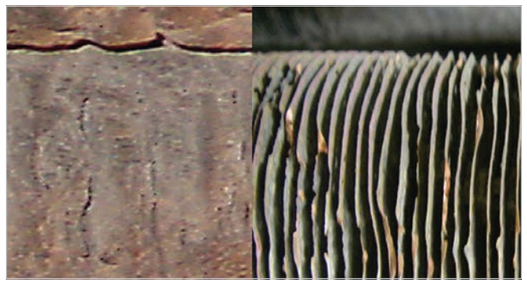

Figure 6. Fouled on the left and cleaned on the right.

Case history: Nitrolance at Brunner Island Power Plant, York Haven, Penn.

Pennsylvania Power & Light's Brunner Island Unit 3 is a 760 MW coal-fired unit. The fouling in the Ljungstrom™ rotary regenerative air preheater was due to fly ash deposits, dust, debris and lube oil that had formed a thick shell over the fin coil surfaces. Since this unit is typically a base-loaded unit, it can only come down for maintenance at scheduled outages. Previous attempted cleanings of the air preheater used water, chemicals and detergents. These methods were ineffective in removing the tenacious fly ash and oil deposits. In operation, this fouling created restricted combustion air flow and led to a megawatt output reduction during certain weather and operating conditions. As an outage approached for the unit, the Nitrolance system was approved by PP&L engineers and the air preheater coils were scheduled for cleaning.

At the start of the unit's outage and the beginning of the Nitrolance cleaning, the system's delivery pressure was carefully adjusted to make sure that the heat exchangers' delicate tube fins (0.012″ thick) were not damaged. Once cleaning commenced, the fly ash and other deposits were removed in seconds and a majority of the air preheater was cleaned in only 12 hours. See the fouled preheater coils in Figure 5 and a direct comparison of the fouled and results of the cleaned coils in Figure 6.

Performance results

After the unit was brought back in service, immediate results showed that the airflow blockage was significantly reduced. In addition, the air flow pressure drop across the air heater was reduced by half. Although still higher than the original design air flow pressure drop, the improvement was significant considering only a portion of the air heater was cleaned due to time limitations. The potential exists for additional improvements by returning to the unit and cleaning 100 percent of the tubes.

Because of the significant improvement of the air heater being brought closer to original design parameters, the plant considered delaying the replacement of the unit 3 air heater, saving PP&L an estimated $2.5 million to $3 million.

Additional benefits of the Nitrolance cleaning system include: increased boiler efficiency, improved unit heat rate, megawatt output increase, reduced house load and $C0_2$ emissions reduction.

References

1. *Hovland, A., et al. 2011, Innovative Cleaning of Air Preheater Coils with Pressurized Liquid Nitrogen (LN2), Proceedings, ASME Power 2011, Denver, CO, July 12 – 14, 2011*
2. *Environmental Protection Agency (EPA), Code of Federal Regulations CRFe, Title 40, Part 423, Steam Electric Power Generating Point Source Category, Aug 3, 2010*

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Eliminate secondary waste stream utilizing pressurized liquid nitrogen

By Elizabeth Foley-Saxon

On the importance of innovation, Albert Einstein once said, "If you do what you always did, you'll get what you always got." This simple yet poignant wisdom has fueled the momentum toward all scientific strides great and small. In the realm of power generation, Conco Systems Inc. of Verona, Pa., has found a better way to address the recurring issue of compromised boiler function in power plants. Using Conco's Nitrolance™ technology, incorporating pressurized liquid nitrogen (LN_2) to clean various types of boiler pre-heaters and heat exchangers surfaces, the issue of compromised boiler efficiency due to fouled and corroded air preheater coils is no longer the tedious endeavor it once was. In fact, the work can now be completed in a fraction of the time with no secondary waste stream.

The motivation to innovate

Cleaning of air heaters in power plants or recovery boilers has traditionally been done with high-pressure water, chemical or steam cleaning methods. These techniques, while effective on moderate air-side fouling of heat exchanger surfaces, are usually ineffective on more tenacious deposits that can develop in coal-fired plants with a buildup of fly ash, dust and oil. If these deposits are not cleaned periodically, the heat transfer in the heaters is reduced, which in turn reduces boiler efficiency and increases a unit's heat rate. Severe fouling on air preheaters and air heaters can even reduce a unit's megawatt output.

Why even bother with cleaning a plant's air heater? The role of a plant's air heater is an important one. A well-functioning air heater improves boiler efficiency by heating the combustion air using available exhaust flue gases. The preheated air accelerates combustion by producing more rapid ignition and also allows the burning of low-grade fuels. For each 50°F increase in boiler inlet air temperature, the boiler efficiency will be increased by 1 percent. Air heaters can increase plant efficiency by up to 10 percent. Do the math. There are real savings to be achieved with maintenance of air preheaters.

Air heater configurations can vary widely in power plants. Some units utilize a Ljungstrom™ type rotary regenerative air heater, or a fixed recuperative tubular air heater. Depending on the configuration, many units might also contain a finned tube air preheater immediately after the forced draft fan. Regardless of the configuration or air heater at work, these units play a critical role in increasing boiler efficiency if they are maintained and kept clean of air-side fouling.

The technology

Enter the Nitrolance cleaning system, which delivers pressurized liquid nitrogen to the cleaning surface of air heaters and rapidly removes deposits through three mechanisms of action: thermal expansion, mechanical pressure and super cooling. The thermal expansion action occurs as the high-density vapor penetrates the cracks and crevices of the fouling deposit. The rapid expansion of gas, combined with the delivered pressure and cold temperature, causes the fouling deposit to break apart and release its bond with the metal. The particulate deposit is then removed, as shown in Figure 2. Mechanical pressure is exerted from the nozzle tip of the Nitrolance as

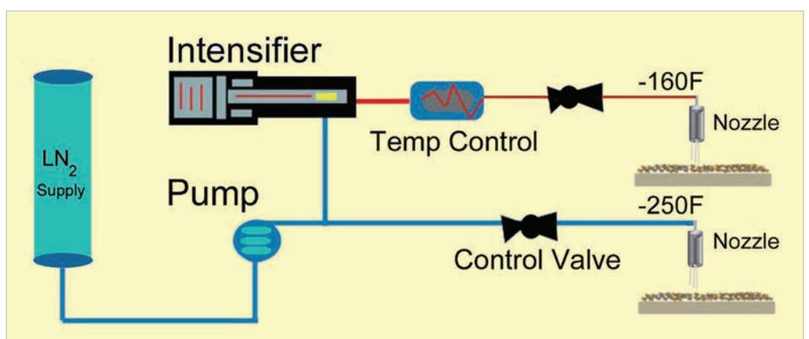

Figure 1. Nitrolance process flow.

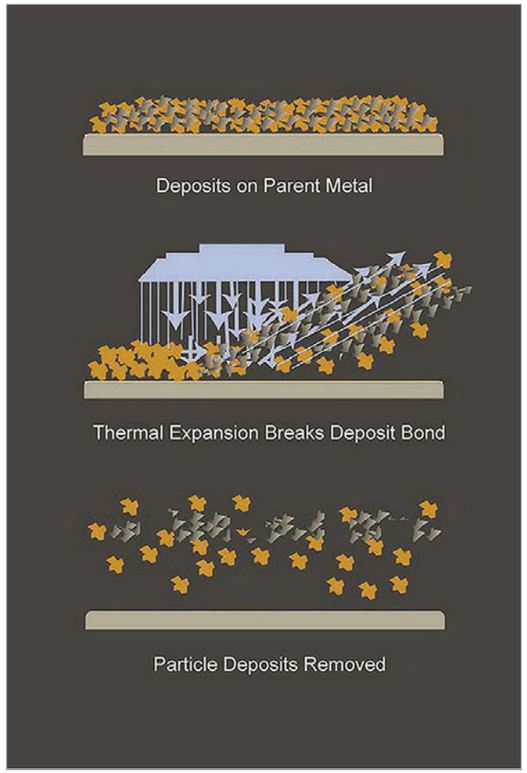

Figure 2. Thermal expansion for deposit removal.

Figure 3. Mobile platform for Nitrolance.

5,000-55,000 psi is applied to the affected surface. The super cooling action results when super cool liquid nitrogen (-160°F to -250°F) makes contact with the metal surface, causing fracturing of now brittle fouling deposits.

LN_2 is effective and safe, base metal grain boundaries remain unaffected

The Nitrolance has shown to be safe to the base metal of air heaters, heat exchangers and other industrial surfaces. An evaluation of the effects of liquid nitrogen on base metal was performed to examine possible changes to the metal's grain boundaries and structure, as well as the potential for shrinkage or modifications of mechanical properties that might result from the cold temperatures. Micro-structural observation and micro-hardness measurements were performed on the material before and after liquid nitrogen cleaning. Cleaning of basic carbon steel induced no micro-structural modifications, as shown in Figure 4. Additional material hardness tests were performed and no changes in the surface micro-hardness of the base metal occured. Shrinkage or modifications of the mechanical properties of the base metal were avoided due to the cleaning process being performed at a relatively fast rate of speed (greater than 10´/minute). Combined with this fast speed and brief contact with the liquid nitrogen, the base metal only dropped in temperature between 9°F and 18°F on average. This small temperature drop induced no notable metal shrinkage and had no notable influence on mechanical properties of the base metal.

No secondary waste, a significant improvement

The Nitrolance cleaning method demonstrates a significant improvement compared to traditional water-based methods of cleaning. The cleaning process is unlike traditional methods that can produce thousands of gallons of effluent. Water-based methods also now require expensive EPA mandated disposal, cleanup and processing. These include air heater cleaning and boiler tube cleaning, boiler fireside cleaning, and many other power plant and industrial plant cleaning processes. The benefit of liquid nitrogen cleaning is that it produces no secondary waste streams. The fouling and deposition waste removed by the Nitrolance cleaning process can be easily vacuumed up. The lack of effluent production by Nitrolance cleaning represents a significant cost savings to power plants compared to traditional water-based methods.

Another consideration, in addition to the cost savings, that zero secondary waste streams represent is in the area of critical path maintenance activities. In several applications, Nitrolance cleaning represented a significantly shorter window needed for cleaning in fixed-length outages compared to traditional water-based cleaning methods. The traditional cleaning methods also required extended cleanup and disposal activities upon completion of the cleaning phase. When necessary maintenance can be completed more efficiently and with shorter disruption to unit function, significant savings will follow.

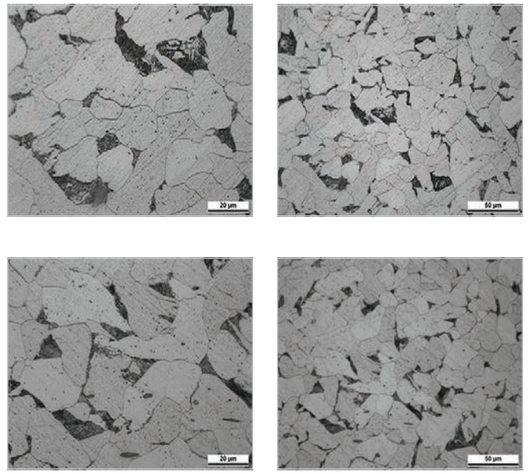

Figure 4. Observation of 3µm diamond polished ASTM A 516 60 before (left) and after (right) cleaning with Nitrolance. The revelation of grain boundaries is made with 4 percent Nital.

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