Technical Bulletin

Reducing time and costs cleaning Heat Recovery Steam Generators

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Introduction
At Flevo Power Lelystad, the old gas fired generators from Electrabel are replaced by new gas fired generators with heat recovery steam generators (HRSG). In a combined cycle plant the gas turbine is driven by the combustion of natural gas. Waste heat of the exhaust gases is recovered and lead through a heat exchanger to generate steam. The steam is lead to the steam turbine to produce electricity.

One of the main concerns is the quality of the steam. Steam turbine blades are very sensitive to the impact of impurities such as particles etc. To optimize steam quality, a pre-commissioning cleaning is therefore required to the full steam and water cycle of the boiler.
Alstom Power has developed a chemical cleaning method, including a steam dumping afterward. This procedure reduces the amount of time and energy required for real steam blowing. The method has proven to be both effective and time and cost reducing at several plants. Vecom Industrial Services BV had gained the contract for the application of this innovative chemical cleaning process.
The purpose of the chemical cleaning job is to realize a clean steel surface with a passivated magnetite layer. This technique should improve steam quality more quickly. The clean surface of the new installation is perfect for starting the further build-up of a natural magnetite layer, which is formed during operations. The chemical cleaning is carried out according VGB guidelines and comprises of a number of successive steps:

Photo 2: erection of the cleaning equipment (850 m^3/h diesel driven pump)

Photo 1: Unit 4 of the Flevo power under construction

- High velocity flushing to remove loose debris.
- Degreasing to remove grease/oil
- An acid phase with hydrofluoric acid to remove iron oxides and silicates.
- Second flushing to replace the acid and remove debris from the acid phase.
- Passivation to form a protective iron oxide film (magnetite).

The steam and water cycle circuits include the “standard” boiler parts and an additional feed water tank. This circuit, with a huge volume of 550 m^3 is rather extraordinary. Due to the absence of an effluent pit, the waste water was collected in barges. The initial volume of the first flushing water was suitable for discharge into the local sewer after filtration. But all other effluents were collected and disposed to a specialized waste water treatment facility in accordance with the Dutch environmental law.

Chemical cleaning operations
The objective of the chemical cleaning was to: remove iron oxides (or rust), silicates, loose dirt and debris, scales and preparing a magnetite layer on the steel surface.
What makes this cleaning job so special, is the acid cleaning of the feed water tank with an additional volume of 140 m^3 which made the system more complex. For this reason, during the acid cleaning phase it was only possible to circulate the full system in one shot, i.e. a total volume to be cleaned exceeding 550 m^3!

To maintain the homogeneity of the acid solution after dosing the concentrated acid, boiler sample check points were fitted on each pressure system and the feed water tank. The chemical cleaning of the steam and water cycle of a boiler is generally done using hydrofluoric acid. For many years major boiler manufacturers use the "VGB guideline R513" as a standard for chemical cleaning. Including high

Photo 3: Temporary lines for chemical cleaning (DN250)

velocity flushing, this method ensures the removal of loose debris prior to the actual chemical cleaning. Before acid cleaning, a degreasing phase is carried out to remove atmospheric scales, grease and oil. This kind of contamination will disturb the acid cleaning process.
Acid cleaning is done using a hot inhibited hydrofluoric acid solution. Although concentrated hydrofluoric acid is highly toxic and corrosive, it is widely used as a chemical cleaning agent. In comparison to other chemicals it offers several advantages. One of the main features is the ability to dissolve silicates (sand etc.). Secondly, the treatment of the waste water is relatively easy and cheaper compared to any other alternative chemical solution. To protect the base material, i.e. the steel surface, an inhibitor is added to the acid solution.
The acid phase is monitored by the analyses of several parameters; hydrofluoric acid concentration and dissolved iron. When the iron concentration stabilizes, all iron oxides are dissolved. Thus completing the acid phase. Due to the fact the feed water tank is to be cleaned in the steam and water cycle, it was not possible to replace the acid by high velocity flushing. Therefore the acid was drained using nitrogen. Nitrogen prevents the formation of flash rust on the steel surfaces. A second blast of high velocity flushing is done to remove any remaining fluorides, prior to passivation. The final step, a cold passivation at alkaline pH, is necessary to form a magnetite layer on the steel surface.

Waste water
For technical reasons, the liquid remains of the cleaning process could not be treated on site. Apart from that, there was not enough space, as the power plant is built on an island. Therefore the waste water was collected in barges, each with a capacity of 2000 T and dispatched to a qualified treatment facility in the Netherlands.

Difficult circumstances
Apart from difficulties regarding the acid cleaning of the feed water tank and the pre-heater, the weather conditions were pretty extreme during this project. Due to the severe winter (with snow and freezing cold) of 2009/2010, special precautions were necessary to execute a chemical cleaning at temperatures below zero.
As water starts to freeze, it expands. This can easily break steel pipes of any wall thickness. Preventing the lines and the boiler from freezing, the boiler and temporary lines were insulated. Heaters and hot air blowers were placed at all sides to keep the temperature of the system above zero. All these measures made it possible to successfully execute the cleaning process under extreme weather conditions.

Finally both units were chemical cleaned according to the procedure and inspections were done by the final customer who was satisfied with the end result of the chemical cleaning.

Photo 4: ice removed from demin-water line

Author: F. van der Kolk & T. van Os
Reactions and/or questions? E-mail: tb@vecom.nl
www.vecom-group.com