Mercury Oxidation Catalyst for PRB-Fired Boilers

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Summary

In 2005, Hitachi and We Energies installed a slipstream reactor (SSR) on Unit 2 at the Pleasant Prairie Power Plant in order to test Hitachi's mercury oxidation SCR catalyst. Unit 2 is a 620MW_g wall-fired boiler, burning 100% Powder River Basin (PRB) fuel, which had a Selective Catalytic Reduction (SCR) system installed in 2003. The SSR is installed next to the existing SCR reactor, and has four layers of mercury oxidation catalyst, which is specifically designed for sub-bituminous fuels containing very low amounts of chlorine.

In order to represent actual SCR operating conditions, the inlet duct of the SSR is connected directly to the inlet of the full-scale SCR, just above the first layer of catalyst. This gas contains an adequate amount of ammonia for the DeNOx process (about 300 ppm). Since the amount of ammonia in the flue gas will influence the mercury oxidation process, this was deemed critical for the demonstration process.

As the gas enters the SSR reactor, a vertical division wall is included which divides the gas into two separate gas streams. One stream is used to extract the catalyst blocks and perform periodic sampling of the catalyst elements. The other stream is used for in-situ measurement of the mercury oxidation performance at periodic intervals during the test program. In addition to mercury oxidation, inlet and outlet NOx and ammonia slip are measured simultaneously in order to ascertain the interaction between mercury oxidation and DeNOx at various conditions and time intervals. Each layer of SSR catalyst is equipped with air sootblowers, which are operated automatically or at user-specified intervals. The SSR is also equipped with electrical resistance heaters to counteract heat loss and to keep the same temperature across all catalyst layers. An induced draft fan and gas flow control damper is provided at the SSR outlet in order to allow for adjustment of the amount of gas flow through the SSR. Instrumentation is provided in the SSR at various locations to measure temperature, catalyst pressure drop and total gas flow. A local control panel is used to provide user interface at the SSR and a PLC is included with for communication with the plant DCS. All of this data is acquired and stored on an hourly basis for future trending and analysis.

Throughout the test program, mercury speciation tests are periodically conducted. The SSR is equipped with test ports at the inlet, outlet and an intermediate point for performing measurements using the Ontario Hydro Method (OHM). Along with mercury speciation, other measurements simultaneously made include HCl concentration at the SSR inlet, ammonia and NOx concentration at the SCR inlet and outlet and total gas flow.

Based on the fuel utilized at Pleasant Prairie, initial measurements at about 1,000 hours of operation indicated an HCl concentration of approximately 4 ppm, which is relatively low for PRB fuels so it is a good representation of a worst-case scenario for mercury oxidation. Based on the location of the duct that connects to the full-scale SCR inlet, ammonia concentrations at the SSR inlet were higher than expected, apparently from stratification of the ammonia in the flue gas at the SCR inlet. Mercury oxidation results were on the order of 95%, despite the low HCl content and higher ammonia concentration, which reduces the overall mercury oxidation. Correction for gas flow, temperature, ammonia and HCL concentration were all made and indicate that the overall mercury oxidation is well within expectations.

Further testing will take place throughout the program in order to continue to monitor mercury speciation and impacts from fuel and gas flow variations as well as catalyst deactivation. This data in combination with the continuous flow and temperature readings being acquired and stored will provide extremely valuable information for evaluating mercury oxidation performance. Initial test data shows very encouraging results; however further testing will be required to determine long-term performance.