Development and Testing of a Novel Coal Preheating Technology for NO_x Reduction from Pulverized Coal-Fired Boilers

Sergei Nester, Stan Wohadlo, Joseph Rabovitser, Bruce Bryan
Gas Technology Institute, 1700 South Mount Prospect Road, Des Plaines, Il 60018-1804
E-mail: Sergei.Nester@gastechnology.org; Telephone: (847) 768-0541; Fax: (847) 768-0600

Dmitri Boulanov, Anatoly G. Tumanovsky, Eugene N. Tolchinsky, Edward H. Verbovetsky
Ministry of Fuel and Power of Russia, All-Russian Thermal Engineering Institute 14/23, Avtozavodskaya Str., Moscow, 109280, Russia
E-mail: vti-furnaces@mtu-net.ru; Telephone: 7 (095) 275-5077; Fax: 7 (095) 275-1122

Robert Lisauskas, Roderick Beittel, Terrence Ake
Babcock Borsig Power, Inc. 45 McKeon Road, Worcester, MA 01610
E-mail: rlisauskas@bbpwr.com; Telephone: (508) 854-4030; Fax: (508) 854-4639

SUMMARY

The METHANE de-NOX® NO_x reduction process for PC Boilers is being developed by the Gas Technology Institute (GTI) under a Cooperative Agreement with the U.S. DOE to provide a cost effective, combustion-based alternative to SCR. The overall project objective is the development and validation of an innovative combustion system, based on a novel coal preheating concept prior to combustion, that can reduce NOx emissions to 0.15 lb/million Btu or less on utility pulverized coal (PC) boilers. This NO_x reduction should be achieved without loss of boiler efficiency or operating stability, and at more than 25% lower levelized cost than state-of-the-art SCR technology. A further objective is to make this technology ready for full-scale commercial deployment in order to meet an anticipated market demand for NO_x reduction technologies resulting from the EPA's NO_x SIP call.

GTI's proven METHANE de-NOX reburn technology is combined with a pulverized coal-preheating approach developed for utility PC boilers by the All-Russian Thermal Engineering Institute (VTI). The technology consists of a burner modification that preheats pulverized coal to elevated temperatures (up to 1500°F) prior to coal combustion. This releases coal volatiles, including fuel-bound nitrogen compounds, into a controlled reducing environment inside of a natural gas-fired PC preheat combustor, which reduces the coal-derived nitrogen compounds to molecular N_2. The preheated coal is converted to a mixture of char and gaseous volatile matter, which is then fired through the main burner into the boiler furnace. Another benefit of the PC preheat approach is that the resulting fuel is easier to fire compared to non-preheated coal due to its initial high temperature and presence of the gaseous fuel components. The quantity of natural gas fuel required for PC preheating is in the range of 3 to 5% of the total burner heat input.

GTI and VTI are joined in the project by Babcock Borsig Power (BBP), providing commercial PC burner design expertise and testing facilities for 3- and 100-million Btu/h preheat burner prototypes in their Coal Burner Test Facility (CBTF) in Worcester, MA.

Initial firing tests of the 3-million Btu/h preheat burner prototype with the PC preheat combustor were conducted with coal in October – December 2001 at BBP. The test coal was a PRB coal out of the Rochelle/North Antelope mine from the Wyodak-Anderson seam in Wyoming. The initial test goal was to preheat PRB coal to the controlled temperature in the range of 1100° to 1400 °F, and to (i) achieve stable, pulsation free operation of the unit; (ii) obtain uniform preheat temperature profile in the PC preheat unit, and (iii) avoid deposition of solids on the walls of the PC preheat chamber.

Two staff members from VTI traveled from Moscow and actively participated in PCP pilot-scale tests from end of November through mid December 2001. Approximately 5,000 pounds of the PRB coal was processed during the initial tests. Test data covering over 50 different operating periods were collected for four different configurations of the PC preheat combustor. Changes in the PC preheat combustor were made to achieve the initial tests goals. The PCP pilot-scale test unit operation was pulsation free, with target preheat temperatures controlled by natural gas firing rate. Inspection of the internals of the PC preheat combustor showed no deposits of solids during operation with PRB coal. Analysis of test data demonstrated that the PC Preheat process has a significant effect on final NO_x formation in the coal burner. The mechanism by which this is effected is not directly controlled by the final preheat temperature, but rather by the residence time of the coal in the high temperature region within the gas-fired preheat combustor. The best PCP pilot test result recorded in initial tests with PRB coal achieved a NO_x emission level of 132 vppm NO_x @ 3% O_2. This test was conducted with the PC burner operated at low excess air levels.

Based on the initial test results, the PC preheat combustor has been modified to increase PC residence time at high temperatures. Additional testing of modified combustor to optimize NO_x control and to determine the full potential of the PC Preheat process for NO_x reduction will be conducted first with PRB coal, then with up three additional U.S. test coals (Central Appalachia, Southern Appalachia and Illinois Basin) and will include firing tests with both direct and indirect PC feeding systems.