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Current Status of Coal Preheating Technology Development for NO_x Reduction from Pulverized Coal-Fired Boilers

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SUMMARY

The Gas Technology Institute (GTI) is developing the PC PREHEAT technology, a NO_x reduction process for pulverized coal-fired boilers, under a Cooperative Agreement with the U.S. DOE. The project is co-sponsored by GRI, GTI's Sustaining Membership Program (SMP), and Riley Power Inc. (RPI), a subsidiary of Babcock Power Inc. Development targets include NO_x reduction below 0.15 lb/million Btu and a levelized cost of electricity reduction of at least 25% compared to SCR. This NO_x reduction should be achieved without loss of boiler efficiency or operating stability, and without post-combustion flue gas cleaning. A further objective is to make the technology ready for full-scale commercial deployment in order to meet market demand for NO_x reduction technologies resulting from the EPA's NO_x SIP call.

In this process, GTI's natural gas-based reburn technology is combined with a pulverized coal-preheating approach developed by the All-Russian Thermal Engineering Institute (VTI). GTI and VTI are joined in the project by RPI. The PC PREHEAT system incorporates a novel PC burner design combined with natural gas-fired coal preheating. The benefits of the technology are:

- NOx reduction to below 0.15 lb per million BTUs with natural gas requirements as low as 3-5% of total heat input
- CO_2 emissions reductions (up to 5% of coal replaced by natural gas)
- Operational benefits including improved boiler turndown ratio, reduced carbon losses, increased boiler efficiency, and stable combustion with low heating value coals

In the new process, a concentrated PC stream enters the burner where flue gas from natural gas combustion is used to heat the PC up to about 1500°F prior to coal combustion. This thermal pretreatment releases coal volatiles, including fuel-bound nitrogen compounds, into controlled, oxygen-deficient atmosphere, which converts the coal-derived nitrogen compounds to molecular N_2 rather than NO. The hot char and pyrolysis products then enter the PC burner, which is modified to burn this highly reactive fuel mixture.

Work has been completed on the design, installation, shakedown and initial PRB coal testing of a 3-million Btu/h pilot system at RPI's Pilot-Scale Combustion Facility (PSCF) in Worcester, MA. Based on these results, necessary modifications to the gas-fired PREHEAT combustor and PC burner were defined and CFD modeling was used to develop and verify revised design approaches for both the PREHEAT gas combustor and PC burner.

Following shakedown of the modified gas combustor alone, a series of successful tests of the new combustor with PRB coal using the original PC burner were completed. NO_x at the furnace exit was reduced significantly with the modified gas combustor, to as low as 150 ppmv with only

36 ppmv CO (all gas data is reported on a dry basis, corrected to 3% O_2). Concurrent with testing, GTI and RPI collaborated on development of two modified designs for the PC burner optimized to fire preheated char and pyrolysis products from the PREHEAT gas combustor.

Both versions of the modified PC burner design were fabricated and installed in the pilot test facility. Testing of the modified pilot system (modified gas combustor and modified PC burner) included 38 tests with PRB coal. NO_x reduction was further improved to levels below 100 ppmv with CO in the range of 35-112 ppmv without any furnace air staging.

Final testing with PRB coal included evaluating the effects of reducing natural gas usage in the gas combustor to the range of 8-10 % of the total thermal input to the system. The best results achieved at the reduced gas usage were a NO_x level of 116 vppm or 0.15 lb NO_x/MMBtu with furnace exit O_2 at 1.9 % and CO at about 106 vppm. Gas usage for commercial-scale systems is expected to be in the range of 3-5 % of thermal input as elimination of preheated coal transfer pipe and the smaller surface to volume ratios of the larger-scale equipment will significantly reduce heat losses.

Several tests with bituminous Central Appalachian coal to evaluate operation of the PC PREHEAT system with caking coal were conducted after completion of tests with PRB. As anticipated, operation of the pilot unit with caking bituminous coal resulted in incidences of plugging in the system, the severity of which depended on the gas combustor operating conditions. Sufficient testing was completed to allow preliminary analysis of the plug formation and operating parameters used, which indicated several approaches to eliminate plugging in future tests, including further changes to the PREHEAT chamber geometry and operating conditions. Several design modifications for plugging prevention were defined, and firing tests with Central Appalachian coal have been started. So far, operation without plugging was achieved at up to 80 % load. NO_x levels were below 150 ppmv at elevated furnace exit O_2. Firing at full load with 2-3 % furnace exit O_2 is expected to meet the NO_x target of 120ppmv.

A CFD model of the 100-million Btu/h Coal Burner Test Facility (CBTF) furnace is developed and will be validated during the commercial prototype testing. The pilot-validated PREHEAT system model is being used to guide the scaleup of the system. When validated through CBTF testing, the combined PREHEAT and furnace models will form a valuable design tool for future commercial installations.

Work on design and construction of a 100-million Btu/h commercial prototype PC PREHEAT system in RPI's 29 MW_{th} Coal Burner Test Facility is currently underway and is planned to be completed by end of November 2003. Firing tests with PRB coal are planned for December 2003.

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