Minimization of Carbon Loss in Coal Reburning

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GE-EER develops an innovative method called Fuel-Flexible Reburning (FFR) to control NO_x emissions from coal-fired boilers while improving byproduct characteristics. The FFR is the synergistic integration of conventional coal reburning and Advanced Reburning with partial in-duct gasification of reburning coal. For partial gasification, the solid fuel can be transported and injected by recycled flue gas stream at 600 – 800 K. This allows the fuel to be preheated and partially pyrolyzed and gasified in the duct and then injected into the boiler as a mixture of coal, gaseous products, and char. Gasification increases coal reactivity and results in lower carbon-in-ash levels. As an option, the gaseous and solid products can be split using cyclone separation. Splitting the reburning fuel stream will allow the volatile matter to be used for reburning and the fixed carbon to be injected into the high-temperature flame zone. The N-agent can be injected into one or several zones of a boiler to increase the efficiency of NO_x reduction.

From an economic standpoint, advantages of the FFR technology are that it (1) uses an inexpensive reburning fuel, (2) does not require micronization mills, and (3) generates a saleable ash byproduct. Economic estimates show that FFR is more cost effective than coal reburning and other technologies with comparable level of NO_x control.

A series of tests was conducted in 1.0×10^6 Btu/hr Boiler Simulator Facility to evaluate FFR performance. Natural gas was used as the primary fuel and coal was used as the reburning fuel. The nitrogen which was used as the reburning fuel transport medium was preheated by a combination of electrical heating and passing the stream through a tube in the furnace. Residence time of the coal stream in the heated nitrogen before entering the furnace was approximately 1 s. Test variables included reburning heat input, which was varied from 10% to 20%, and transport stream preheat temperature, which was varied from ambient to 700 K. Tests showed that coal was almost as effective reburning fuel as natural gas. Tests also demonstrated that NO_x reduction increased with increasing preheat temperature, most notably at the higher reburning heat inputs. Preheating also decreased carbon-in-ash levels.

The coal reburning chemistry-mixing model was developed to assist in FFR optimization. The model was based on a detailed kinetic model for the gas-phase reactions but also involved important heterogeneous reactions. These reactions included devolatilization of coal, oxidation of soot and char by O_2 and oxygen-containing radicals, reduction of NO on the char and soot surfaces, and radical recombination on the char and soot surfaces. The reburning process was represented as a series of two plug flow reactors describing reburning fuel and overfire air injection. Mixing times in the reburning and burnout zone were estimated using single jet in crossflow model. Modeling qualitatively described experimental data and suggested that FFR efficiency depended on volatile content in coal, temperature of gasification, gasification residence time, temperature of the reburning fuel injection, and the amount of the reburning fuel. Modeling predicted that carbon in ash content was reduced when reburning fuel was partially gasified before the injection.