Oxygen-Enhanced Coal-Based Reburning

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Summary

In most reburning applications natural gas is used as the reburn fuel due to its ready conversion to hydrocarbon radicals and ease of burnout. Using natural gas as the reburn fuel, however, leads to higher operating cost than if a cheaper fuel, such as coal, can be used. However, coal-based reburning can lead to a significant increase in the unburned carbon in the ash, due to incomplete burnout of the reburn coal. This problem is related to the difficulty of burning out the residual char from the reburn fuel in the short space available above the reburn zone. A novel oxygen-based technology[1] can minimize this problem while enhancing the effectiveness of coal as a reburn fuel.

The basis of this novel concept is Praxair's patented thermal nozzle technology[2]**.** The thermal nozzle is used to create a high velocity oxygen enriched stream. Oxygen is fed into a burner and combusted with a small amount of natural gas to create a hot oxygen-rich gas. The hot oxygen gas then passes through a nozzle, creating a high velocity gas stream. The final gas composition, temperature, and velocity are controlled by the amount of natural gas fed to the burner and the nozzle diameter.

Hot oxygen can be used to enhance coal-based reburning by enhancing devolatilization of the reburn fuel – increasing the amount of gaseous products available for reburning and reducing the amount of residual char that must be combusted. For example, hot oxygen and reburn coal can be reacted in a chamber outside the furnace to produce a hot gaseous reburn fuel. The chamber would then open directly into the furnace such that the reburn fuel is injected into the furnace at high velocities to rapidly mix with the furnace flue gases. The conditions in the reactor would be optimized to create the optimal reburn fuel for use in the furnace.

To explore this concept a series of bench-scale experiments were performed to determine the effectiveness of hot oxygen in enhancing coal devolatilization. In these experiments an eastern bituminous compliance coal was burned under a range of conditions. An air-coal mixture was transported to a mixing section where it was entrained into the hot oxygen and ignited. The burning mixture then entered a refractory lined chamber with thermocouples embedded in the wall to measure wall temperatures. The hot combustibles exited the combustion section and burn with surrounding air.

The gas composition leaving the refractory lined combustor was measured by inserting a water cooled gas probe far enough into the combustor to avoid dilution by any surrounding air that might be drawn into the chamber. The gas sample is cooled to ambient temperature and passed through a filter to remove particulate and condensed moisture. Particle samples were taken using a nitrogen-quench, water-cooled probe. The particulate samples were burned out in a furnace to determine the loss on ignition (LOI), which was then used to determine the conversion of the combustibles.

Data was obtained on the composition of the gas resulting from mixing the hot oxygen with the coal (and transport air). These data suggest that as the stoichiometric ratio in the chamber is reduced more of the carbon is found as CO, and to a lesser extent CH_4, instead of CO_2. The hydrogen concentration also increases as the

stoichiometric ratio is reduced. This trend is particularly important since for hot oxygen to promote coal-based reburning it is critical that the coal is devolatilized/gasified rather than simply combusted with the hot oxygen. These results indicate that the hot oxygen facilitates devolatilization and partial oxidation of the coal to produce a gas that can be used to reduce NOx emissions. The conversion of the carbon to combustibles to the gas phase decreases as the stoichiometric ratio is reduced, but exceeds 50% in all cases.

In general these data support the premise that hot oxygen can be used to enhance coal-based reburning. Even with an unoptimized reactor design mixing hot oxygen with the coal converted the majority of the combustibles to gas phase species that could readily react to reduce NOx. By optimizing the reactor design, it should be possible to increase the coal conversion and minimize the operational problems, such as slagging. Optimizing the hot oxygen composition and temperature, as well as adding other gasses could also enhance the conversion. Clearly the technology shows promise to enhance coal-based reburning.

1. US patent 5,266,024 "Thermal Nozzle Combustion Method"

2. US patent 6,206,949 “NOx Reduction Using Coal-Based Reburning”

3. Riley, M.F., Strayer, T.F., and Terchick, A.A., “Effect of Direct Oxygen Injection on Combustion of Injected Coal”, Proceedings of the Second International Congress on the Science and Technology of Iron Making, Iron and Steel Society, Warrendale, PA, 1998