

# Design of Reburning Fuel

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## Summary

Pilot and full-scale demonstration research in the last three decades, however, seemed to suggest that reburning possesses a 60% NO reduction floor. Although NO can be effectively reduced in the reburning zone, nitrogen-containing reaction products from this second stage of the process are likely the precursors of the NO production in the burnout zone, which ultimately attribute to the observed NO reduction floor. During *natural gas* reburning, hydrocarbon free radicals, including C·, CH· and CH<sub>2</sub>·, effectively reduce NO to HCN, a major reaction products in reburning zone. A significant portion of HCN oxidizes to NO in the burnout zone that limits the overall NO reduction efficiency. During *coal* reburning, a significant portion of the char nitrogen oxidizes to form NO in the burnout zone. To break these reduction barriers, advanced reburning must involve means for simultaneously minimizing NO, and its reaction intermediates, i.e., HCN and char.

Recent studies of heterogeneous reburning, i.e., reburning involving a coal-derived char (see, e.g., Chen and Tang, *AIChE Journal*, **47**(12), 2781-2797, 2001; Chen and Ma, *AIChE Journal*, **42**(7), 1968-1976, 1996), have revealed its variables, kinetics and mechanisms. This information renders it possible to the design of a highly efficient reburning fuel. Young chars derived from low rank coals, lignite and sub-bituminous coal, contain catalysts that effectively reduce not only NO, but also HCN. Gaseous CO, a rich product of incomplete combustion in a reburning stage, effectively scavenges surface oxides and regenerate the carbon active sites on the char surface.

A low cost, mixed fuel containing these multiple functions has been designed and tested in a simulated, bench-scale reburning apparatus at 1100°C with a 0.2 s residence time. Methane is usually chosen as one of the components for its capability of converting NO to HCN and for the speedy production of CO for scavenging surface oxides. A second component is chosen mainly for the effective HCN reduction, including lignite char, lignite ashes, ashes of sub-bituminous coals, ashes from utility boilers, ashes from Bunsen burners, and others. In general, ashes of sub-bituminous coals are less reactive than those from lignite. Ashes collected from utilities are less effective than those from laboratory by a Bunsen burner, probably due to the differences in their temperature history and level of sintering. Ash collected from a bag-house seems to be more effective in HCN reduction than ashes from electrostatic precipitators; moreover, the ash from a bag-house is capable of reducing another reaction intermediate, NH<sub>3</sub>. Nevertheless, HCN reduction always increases with higher amount of this secondary fuel. Remarkably high efficiencies of NO and HCN have been observed. For instance, when methane and ashes from lignite-fired power plants are used, about 90% of NO is converted to species other than NO and HCN.

Other low-cost fuels have also been tested and its reactivity in HCN conversion seem to be even better than those mentioned above. Our quantifications of total fixed nitrogen (NO, HCN and NH<sub>3</sub>) suggest that, by careful design of a mixed fuel, reburning technology is likely to meet the Environmental Protection Agency's regulation of removing 85%, or 0.15 lb/million Btu, of NO<sub>x</sub> in a three-stage reburning process. In addition to these progresses, potential technical difficulties of this approach and their remedies will be discussed in the Symposium.