Testing of switchgrass and sericea co-milled with coal in southern research and southern company's combustion research facility

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The cofiring of biomass with coal represents an opportunity to replace a portion of the fossil carbon in coal with carbon sequestered in biomass, thereby reducing the overall burden of atmospheric CO_2 generated from coal combustion. Because coal is displaced by biomass, and biomass typically contains low levels of sulfur and nitrogen, overall SO_2 and NO_X emissions are reduced. There is also the possibility that NOx emissions from coal-biomass mixtures may be reduced by more than the fuel nitrogen that is displaced by the addition of biomass. This is because biomass has a much higher volatility than coal and during the first stages of combustion biomass may tend to aggressively scavenge oxygen, producing an overall leaner flame and lower NO_X emissions. Thus, the introduction of volatile biomass with coal may effectively stage combustion by producing the same physical environment as is found near a low-NO_X burner.

The studies reported here evaluated the combustion properties of switchgrass (var. Alamo) and Sericea Lespedeza when mixed with coal in as great a concentration as could be pulverized and delivered to the Southern Research Institute/Southern Company (SRI/SCS) Pilot Scale Combustion research facility (CRF). For these tests, the combustor was operated at a heat rate of 3.6×10^6 Btu/hr in a typical low-NO_X configuration (15% overfire air) at nominal furnace exit oxygen levels of 2.5%, 3.5%, and 4.5%.

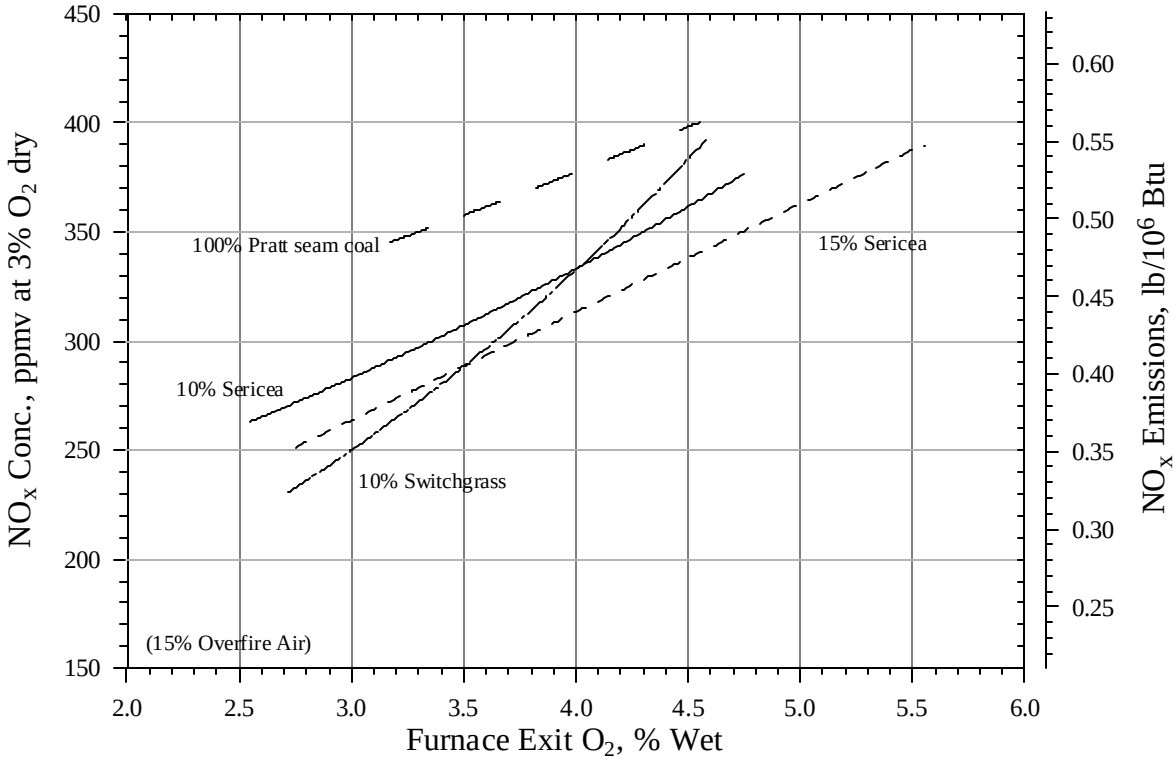
Milling and Combustion

All mixtures were easily pulverized. Only slight changes in the vane settings of the mill classifier were required to mill any of the switchgrass or sericea-coal mixtures. In terms of combustion, either blend was indistinguishable from the base Pratt seam coal. No significant slagging was observed in the furnace and no significant fouling was observed in the convective section of the combustor for any test condition. With respect to slagging and fouling, residues left from the combustion of these mixtures were essentially indistinguishable from those left from the combustion of 100% Pratt seam coal. Thus, of the nominal switchgrass and sericea - Pratt seam coal mixtures that were tested, it is likely that greater levels of biomass could be burned without difficulty.

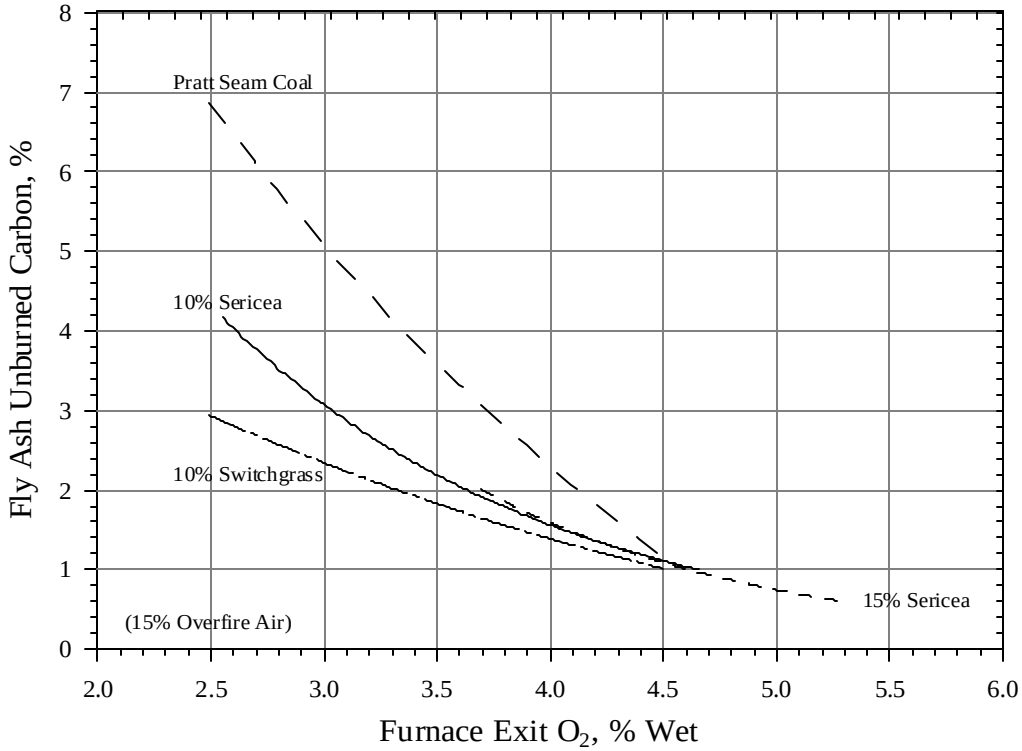
NO_x and Combustion Efficiency

The first of the two attached graphs shows that NO_X emissions were reduced from 15% to over 20% by the addition of either biomass, far more than the maximum 7% reduction in fuel nitrogen that came from replacing up to 15% of coal with biomass. A possible explanation is that because biomass has a much higher volatility than coal, during the first stages of combustion biomass may tend to aggressively scavenge oxygen. This produces an overall leaner flame with lower NO_X emissions. Carbon present in fly ash (a direct measure of combustion efficiency) was determined for each fuel mixture by CHN analysis of isokinetically sampled fly ash from the combusted fuels. As the second graph shows, at 3.5% furnace exit oxygen (a typical boiler condition), fly ash from 10% switchgrass comilled with Pratt seam coal contained 50% less unburned carbon (UBC) than fly ash from pure Pratt seam coal. For 10% or 15% sericea comilled with Pratt seam coal, UBC was 39% less than was found in fly ash from the pure coal.

This work was made possible by US Department of Energy Cooperative Agreements DE-FC36-98GO10349 and 1SEP00 DOE 01 (the last administered by the State of Alabama Department of Economic and Community Affairs).



NO_X emissions for switchgrass and sericea comilled with Pratt seam coal



Unburned carbon in fly ash for switchgrass and sericea comilled with Pratt seam coal