NO_x, Fine Particle and Toxic Metal Emissions from the Combustion of Sewage Sludge/Coal Mixtures: A Systematic Assessment.

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By

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ABSTRACT

This research project focuses on pollutants from the combustion of mixtures of dried municipal sewage sludge (MSS) and coal. The objective is to determine the relationship between 1) fraction sludge in the sludge/coal mixture, and 2) combustion conditions on a) NOx concentrations in the exhaust, b) the size segregated fine and ultra-fine particle composition in the exhaust, and c) the partitioning of toxic metals between vapor and condenses phases, within the process. To this end we shall use an existing 17kW downflow laboratory combustor, available with coal and sludge feed capabilities. The proposed study will be conducted in concert with an existing ongoing research on toxic metal partitioning mechanisms for very well characterized pulverized coals alone. Both high NOx and low NOx combustion conditions will be investigated (unstaged and staged combustion). The proposed work uses existing analytical and experimental facilities and draws on 20 years of research on NO_x and fine particles that has been funded by DOE in this laboratory. Four barrels of dried sewage sludge are currently in the laboratory. Insofar as possible pertinent mechanisms will be elucidated. Tradeoffs between CO_2 control, NO_x control, and inorganic fine particle and toxic metal emissions will be determined.

For the First Quarter of this three year project work has centered around recruiting a graduate student to take responsibility for execution of portions of the research, and modifying the furnace and supporting equipment to allow the combustion of coal/MMS mixtures. We have readied the analytical panel for measuring NO_x and other gaseous pollutants. We expect initial experiments for data gathering for coal/MSS mixtures to commence in the next Quarter.

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OBJECTIVES

The objective of the proposed research is to gain insight and understanding into the harmful air emissions that arise during the combustion of mixtures of dried municipal sewage sludge (MSS)

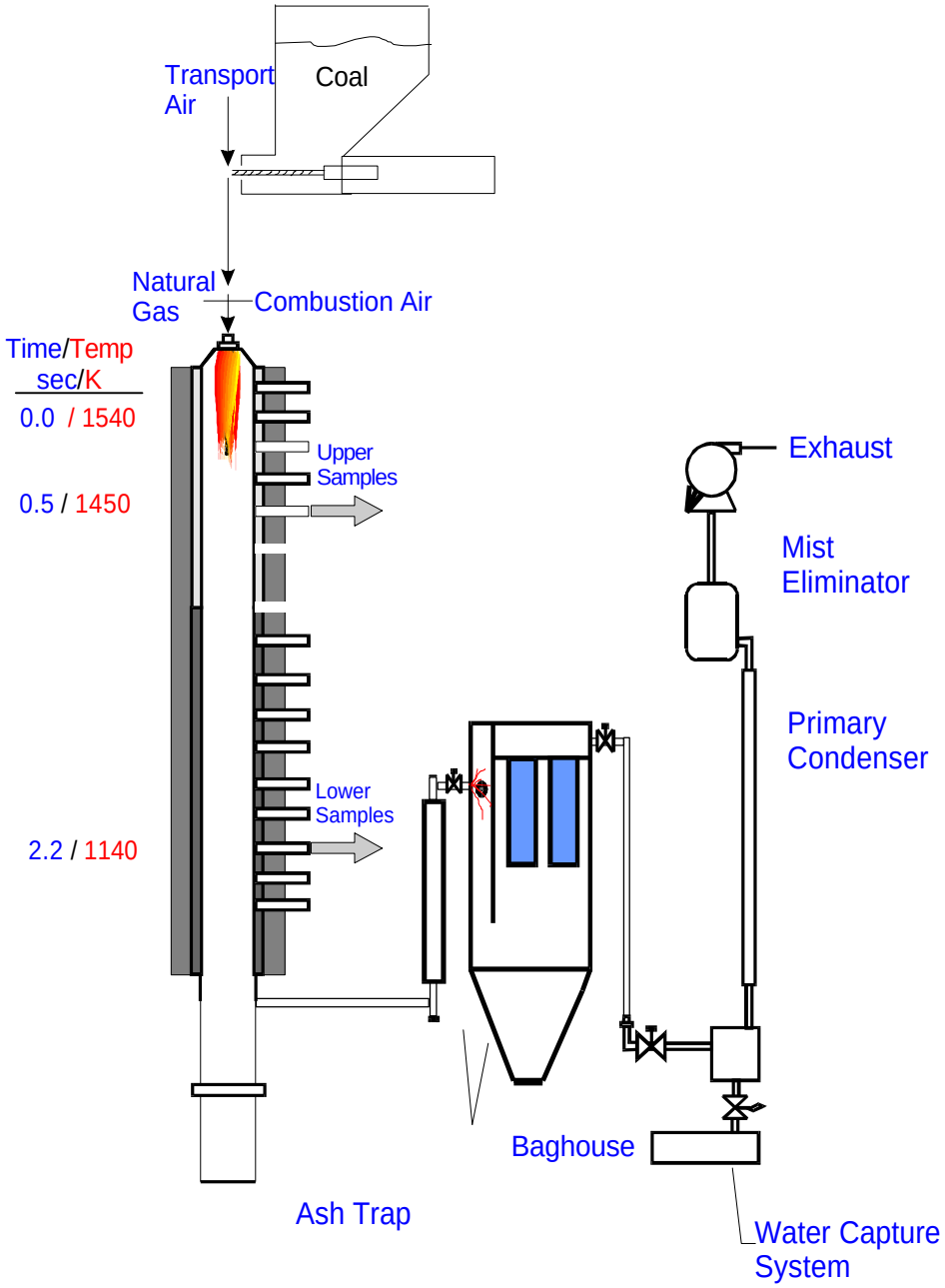

Figure 1: Schematic of downflow laboratory combustor. Dried sewage sludge and pulverized coal will be fed separately through two feeders and mixed prior to introduction in the burner.

and pulverized coal. Specifically, we wish to ascertain the emission tradeoffs between CO_2

mitigation through the use of biomass, and the potential local increases of NO_x, fine particle, and toxic metal emissions that are likely.

BACKGROUND

The combustion of sewage sludge, although CO_2 neutral, and therefore benign from a global warming point of view, may have other serious environmental repercussions. One of these might be increased emissions of NO_X, although it is believed that combustion modifications should be sufficient to handle them, since they are due to increased volatile fuel nitrogen. Another, more serious, consequence of sewage sludge combustion is the release of potentially very toxic fine particles into the air. Preliminary data suggests that inhalation toxicity may be due to high concentrations of zinc in sewage sludge ash. Lastly, the release of toxic and mutagenic metals concentrated among fine particles, may also be a problem. Needed is a general systematic assessment of how combustion of sewage sludge with coal affects the release of all three pollutants: NOx, fine particles, and toxic metals.

APPROACH

The overall approach to be followed is to pursue a systematic experimental test plan in which various mixtures of sewage sludge and coal are burned in a 17kW downfired laboratory combustor (shown on Figure 1), under unstaged and staged combustion conditions.
The combustor can burn coal/sludge mixtures under self sustaining conditions and with simplified aerodynamics but practical time temperature histories. This ensures that particle, gas and metal concentrations are similar to those in full scale units and that the emission results obtained have general applicability. The intent is to investigate NO_x, fine particle and toxic metal emissions under simplified but practically relevant aerodynamic conditions. Rather than testing the emissions from *specific* burners, we plan to look at two extremes of burner mixing patterns. One extreme is to mix all the coal and sewage sludge with all the air rapidly before ignition. This represents intensely mixed combustion processes. It will have high NOx emissions. The other extreme is to stage combustion in two stages, where the first stage is fuel rich at a stoichiometric ratio of 0.8, and the second burnout stage is at a stoichiometric ratio of 1.2, achieved by the addition of burnout air. It should have low NOx emissions. The effect of staging on the size segregated fine particle composition is not known. The insight gained by investigating these two extremes, should be sufficient to relate these small scale results to those expected from field units.

PROGRESS MADE THIS QUARTER

Work has been initiated and a graduate student has been assigned to this project. She is Jessica Egleton who is initially completing her MS in Chemical Engineering. The furnace was partially rebuilt during this quarter, according to the schematic shown on Figure 1. We have installed the newly acquired air pre-heater, together with the required controls. We have installed the K-Tron loss-in-weight solids feeder, and after some problems, have made it work according to specifications. We have tested the furnace burning coal alone. The system appeared to work well. The analytical train was checked out and was calibrated and it also worked according to specifications.

ANTICIPATED PROGRESS FOR NEXT QUARTER

During the coming quarter we expect to begin experimentation with sewage sludge coal mixtures. Our first tests will be concerned with combustion of MSS + natural gas and MSS (50% by mass) and an Ohio coal. Particulate samples will be withdrawn at Port 14, and size segregated in a low pressure impactor for subsequent analysis. We shall measure NOx for all four cases (gas, gas plus MSS, coal, coal plus MSS). Metal analyses will be by Flame Emission AA and Graphite Furnace AA.