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The Role of Pore Structure on Char Reactivity

DOE Grant No.: DE-FG 22-91PC91294

Quarterly Progress Report

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Prepared for U.S. Department of Energy

Morgantown Energy Technology Center

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Morgantown, WV 26507-0880

Attention: Wu K. Lan

Date Submitted: July, 1993

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Introduction

Studies will be conducted on coal chars in the electrodynamic balance to examine the role of mesopore structure on reactivity. Larger particles will also be examined using a fluidized bed to examine diffusion control reactions. Soots will also be investigated to examine the role of meso- and micro-pores without macro-pore interference. These studies will allow a full range of particles sizes and temperatures to be investigated and eventually modelled.

Progress Report

The project continues with to focus on the development and refinement on the equipment that will provide the data needed for modelling. The fluidized bed system is fully operational, although only a few experiments have been run.

Work has continued on the electrodynamic balance (EDB) for use in measurement of char micropores. While refinements of the system have proceeded at a reasonable pace, and many control tests have been made to characterize the system. The control system still does not work well without heating by the laser source. Currently, Gernot Kramer, the post doc who has been instrumental in getting the system to the point it is at is visiting Israel and the Labs of Professor Baziv. Professor Baziv has done collaborative research with the MIT group before, and he currently has an operational EDB. To control the temperature and stabilize the particle system, he uses a digital system operating at a control frequency of approximately 25kHz to control his system. This is much faster than the system used at MIT, and may offer significant advantages.

Most of the work in the last three months has focused on the fluidized bed. The system is essentially complete, and tests have been run to determine the extent of back-mixing and delay time. No significant problems were found with the system. The cage is constructed with stainless steel mesh and hypodermic tubing. The current cage has performed well in trial runs, an example of which is given in Figure 1. However, on examination of the particles and the samples, it was found that the mesh size with 1 mm holes was too large to withdraw fragmented particles. Various cages have been constructed with mesh openings ranging from 24x24 mesh (0.28 mm) to 50x50 mesh (0.7 mm). These cages have yet to be tested, although it is expected that they will offer no significant problems. The current tests deal with duplicating the work of Sunback in order to test the bed and to more fully detail the fragmentation she encountered and compare this to macropore formation.

As shown in Figure 2, the work has already shown some new facets to the work of Sunback. As can be seen, the CO₂ profile is nominally flat, with only a slight gradient. This run would seem to confirm

that the fragmentation of large particles is such that a "steady state" is achieved, where the generation of CO₂ spikes due to fragmentation is masked by numerous spikes. However, an alternate explanation concerns the fact that many of the spikes are less than 1000 ppm. It is also possible that the fragmentation simply does not register due to the higher concentration of CO₂ which tends to hide variations (At a scale maximum of 30,000 ppm, the 1000 spike that produced a 33% rise with a 3000 ppm maximum only produces a 3% rise.). These two explanations will be further explored by using the FTIR to check on the analysis figures in further runs

The analysis of pore structure of Newlands coal is being conducted using the facilities in Italy. The Newlands char was combusted to approximately 25, 40 and 60% burnout, and we are currently waiting for these results. The pore structures of these chars may clear up some of the questions that arose during NO_x generation modeling work. Two other coals have been obtained for study in the fluidized bed, a West Virginia coal and an Illinois #6 coal. Analysis of these coals have not been as of yet, although approximate analysis are available to proceed with our work until analysis is completed.

Future Work

The fluidized bed will be used to obtain chars at various stages of combustion in a fluidized bed. This will be used to compare and evaluate the role of fragmentation versus macropore opening in the coals used in this study. The data obtained from various surface area measurements will then be used to evaluate various model performances.

References:

Sundback, C.A., Fragmentation Behavior of Single Coal Particles in a Fluidized bed, PhD Thesis, MIT, 1984

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Figure 1. Example of Fluidized bed system combustion of a single 6 mm particle of West Virginia coal (5% Oxygen at 1073 K). The increases in CO₂ concentration is due to increased combustion rates, leading to increased carbon dioxide production. This can be seen at approximately 4 minutes time, where a 1000 ppm rise can be seen.

Figure 2. Combustion of a single(7 mm) coal particle of Illinois #6 coal(12% Oxygen at 1123 K), with volatile peak cut off. The CO₂ profile is quite flat for the run, with only minor variations in concentration.

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