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**PARTICULATE BEHAVIOR IN A CONTROLLED-PROFILE PULVERIZED COAL-FIRED
REACTOR: A STUDY OF COUPLED TURBULENT PARTICLE DISPERSION AND
THERMAL RADIATION TRANSPORT**

Quarterly Technical Progress Report
For Period March 15, 199³₂ to June 14, 1993

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FORWARD

This report summarizes technical progress during the seventh quarter (March 15, 1992 to June 14, 1993) of a three-year study conducted for the Department of Energy (DOE) under contract number DE-FG22-91PC91308. The principal investigators for this work are Dr. Mardson Queiroz and Dr. Brent W. Webb; Dr. Clifford Smith is the technical representative for DOE.

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ABSTRACT

During the seventh quarter progress has been made in the following areas: instrumentation development and testing, and reactor preparation trial runs. Refurbishment of the Controlled Profile Reactor was initiated this summer and is completed. Installation of a new feeder and wall heaters were concluded as well.

1. OBJECTIVES AND SCOPE

1.1 BACKGROUND

Improved understanding of the fundamental processes involved in pulverized-coal combustion is needed to make the energy extraction more efficient and the combustion byproducts environmentally safe. While the characterization of the local particulate behavior (concentration, size, and velocity) is important to the understanding of virtually all processes in a pulverized coal-fired furnace, it influences in a more direct way the turbulent particle dispersion and thermal radiation heat transfer. Yet the local particulate dynamics have gone relatively unaddressed, primarily because of lack of adequate instrumentation to carry out such a study. With recent advances in optical techniques such an effort is now possible. This proposal seeks to characterize the local particulate concentration, velocity, and size distribution in a well-controlled, parametrically-varied laboratory-scale reactor using a new laser diagnostic technique. This newly-developed technique is the only one currently available for the investigation of aspherical particles. The particulate data will be collected simultaneously with local gas temperature and wall radiant heat flux distributions.

1.2 OBJECTIVES

This report describes recent progress in a fundamental, three-year investigation of the coupled problem of turbulent particle dispersion and thermal radiation transport. The project's objective is to make measurements of particle size, velocity, number density, temperature and wall radiant heat flux in a parametrically-controlled reactor presently existent at Brigham Young University (BYU). Although the study proposed here is primarily designed to provide experimental data not currently available for the evaluation of turbulent particle dispersion and radiation models, comparisons of analytical predictions and the experimental data obtained will be performed, using appropriate submodels integral to comprehensive pulverized-coal combustion codes existent at BYU.

1.3 TECHNICAL APPROACH

To accomplish the above objectives, the project is divided in the following tasks:

- Design and fabrication of a modified section for the BYU controlled-profile reactor, which will allow access of several probes to be used in the proposed study.
- Design and fabrication of a two-color pyrometer and cooled probe for local particulate temperature measurement.
- Characterization of the non-reacting turbulent flow field in the reactor using the PCSV-P probe, which will serve as an input during the turbulent particle dispersion submodel validation.
- Literature review dealing with particle dispersion and radiation transport in support of the model validation effort.

- Perform the parametrically-controlled measurements in the controlled-profile reactor.
- Experimental data analysis.
- A comprehensive comparison of experimental data and model predictions.
- Final report.

2. SUMMARY OF TECHNICAL PROGRESS

2.1 CONTROLLED PROFILE REACTOR

Air preheaters have been installed which maintain the combustion inlet air at temperatures above 500 F. Combustion air preheating is required to maintain a stable flame with the coal currently in use. Feedback control on the preheaters has been added to ensure a constant inlet temperature.

A new coal feed system has been implemented which yields only a 4% error in feedrate over 10 second intervals. The new system incorporates a small conveyor whose weight is sensed by a low-capacity load cell and driven at a constant speed. The conveyor receives coal from one of the existing Acrison auger feeders and the feeder is controlled to maintain a constant weight of coal on the conveyor. Pulsing due to clumping off of the end of the conveyor is eliminated by dropping into a vibrating chute. The coal then drops into the low-pressure side of a venturi nozzle to entrain it in the primary air flow. This new coal feed system reduces the error in feedrate measurement from 15% to 4% over 10 to 15 second intervals. Significant pulsing from the previous coal system caused serious flame instability which prevented selection of a stable test condition. The new feed system will be used to establish good test conditions in the next few days.

One or two conditions will be chosen for tests to assure repeatability and to give a large database for statistical analysis. Particle size, velocity, and concentration will be measured as well as local gas and particle temperatures.

In order to accurately document the operating conditions pressure transducers have been replaced and recalibrated to obtain air flow rates. The air flow rates and the coal composition analysis of the Pittsburgh 8 coal provide the basis for stoichiometric calculations. The new system of acquiring coal feedrates allows instantaneous stoichiometric calculations. The implementation of this system and the new feed system will provide accurate time resolved data for operation and control of the reactor.

2.2 TRANSMISSOMETER DEVELOPMENT

The construction of the new transmission probe is now complete. It will be used in combination with the Insitac Particle Concentration, Size, and Velocity (PCSV) instrument in resolving particle number densities below the 1 μm lower bound of the PCSV. The probe measures transmission of a 1 mm diameter HeNe laser beam through a diagnostic window. Temperature sensitivity of the beam detector has been minimized by encasing it in a water-cooled enclosure. Data acquisition is accomplished by sample-and-hold of the detector signal through a 12-bit National Instruments A/D board at a user-defined

sampling frequency. Passive analog frequency filters have been used with good success in eliminating high-frequency background signal noise. Other instruments developed and repaired during this quarter include: (1) the suction pyrometer which was recently rebuilt to eliminate leaks that developed from corrosion. The new probe will be flushed out after every test to prolong its life. When not in use it will be filled with oil; (2) the two color pyrometer has been recalibrated using the muffle furnace. Preliminary tests in the CPR indicate that particle temperatures can be resolved to within 40 degrees Centigrade. The data acquisition for the two color pyrometer will be done with a 16-bit National Instruments board in a Macintosh computer.

4. APPENDIX

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