TITLE: Optimization of Coal Particle Flow Patterns in Low NO_x Burners

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OBJECTIVE

The proposed research is directed at evaluating the effect of flame aerodynamics on NO_x emissions from coal-fired burners in a systematic manner. This fundamental research includes both experimental and modeling efforts being performed at the University of Arizona and at Purdue University. The objective of this effort is to develop rational design tools for optimizing low NO_x burners to the kinetic emissions limit (below 0.2 lb./MMBTU). Experimental studies include both cold and hot flow evaluations of the following parameters: flame holder geometry, secondary air swirl, primary and secondary inlet air velocity, coal concentration in the primary air and coal particle size distribution. Hot flow experiments will also evaluate the effect of wall temperature on burner performance. Cold flow studies will be conducted with surrogate particles as well as pulverized coal. The results will be used to predict particle flow patterns in the hot-flow furnace as well as to estimate the effect of flame holder geometry on the furnace flow field. The cold-flow results will be compared with Fluent computational fluid dynamics model predictions and correlated with the hot-flow results with the overall goal of providing insight for novel low NO_x burner geometry's.

ACCOMPLISHMENTS TO DATE

Cold-Flow Studies (Purdue University)

– Completed construction and initial testing of cold-flow furnace chamber. The chamber is 18” wide, 40” tall and is equipped with 16” by 30” Pyrex windows for optical access. The chamber is equipped with a removal honeycomb top for free jet experiments that can be replaced with a solid top when conducting recirculating experiments.
– Installed and debugged 3D traversing LDV/PDPA system.
– Developed dual particle feed system for laser analysis of both gas flow fields and particle flow fields within the cold-flow chamber. Gas stream characteristics are measured using 1-2 μm aluminum oxide particles. At present, glass beads 50-70 μm in diameter are used as model particles.
– Conducted single-phase free jet experiments and compared experimental results with FLUENT simulations and literature values. Mean and fluctuating velocity fields and Reynolds stress profiles match published experimental data for round, free jets.
– Conducted two-phase experiments to explore the effect of solids loading on the particle fluctuating velocity

- Developed an effective discrimination procedure to distinguish between the scattering signal from the non-spherical, aluminum oxide tracer particles (gas phase) and the larger, spherical glass beads (particle phase).
- Compared the location of the recirculating regions and the extent of recirculation in confined jet flows predicted by Fluent CFD models to published experimental data to evaluate how modern CFD codes agree with data and existing simple (adhoc) pseudo-analytical predictive models such as Thring and Newby (1953), Field *et al* (1967) and Craya and Curtet (1955)

Hot-Flow Studies (The University of Arizona)

- Nearing completion of the 18” ID hot wall furnace. The furnace is equipped with a 3’ hot section that consists of multi-zone ceramic heaters capable of attaining 1300K. It is equipped with a full length quartz window for flow visualization studies and a translating stage for axial/radial sampling.
- Constructed an axial flow burner with interchangeable combustion air sleeves. This burner design can maintain constant momenta for different combustion air temperatures or we can vary air velocity at constant temperature. The base case sleeve can attain velocities between 74 and 88 fps. The minimum velocity is 19 fps at 590K and the maximum velocity is 103 fps at 700K.
- Installed and debugged a combustion air pre-heater to produce burner inlet air temperatures from 590 to 700K.

ARTICLES/PRESENTATIONS

J.L. Sinclair, G.E. Ogden, J.O.L. Wendt, "Optimization of Coal Particle Flow Patterns in Low NOx burners", Presented at the 1999 American Flame Research Committee Spring Meeting, Tucson, Arizona, April 11-13, 1999.

STUDENTS

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