Title: Passive Control of Particle Dispersion in a Particle-laden Circular Jet using Elliptic Co-annular Flow: A means for Improving Utilization and Emission Reductions in Pulvarized Coal Burner.

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Abstract

In pulverized coal combustor, the conversion of nitrogen containing species to NO_x strongly depends on the local stochiometry. Hence it is desirable to control both the preferential concentration of particles into clumps and the flinging of particles away from the flame zone. Passive control of preferential concentration of particles using nonaxisymmetric jet exit geometry is an attractive solution. For instance, injection of longitudinal vortices in the jet shear layers from an elliptic coflow can control the preferential dispersion of coal particles since longitudinal vortices are formed in the elliptic jet due to asymmetric self-induction of the vortex ring structures. The project is investigating a passive control strategy of particle dispersion in coal-laden jets using elliptic co flows. The control methodology developed through the project will be important to improve the design of pulverized coal burners where non-homogeneity of particle concentration causes increased NO_x formation.

A coaxial jet flow rig has been designed, fabricated and qualified for conducting proposed experimentations. Compressed air enters the jet flow facility through three separately metered lines: inner flow line, the annular flow line and/or the smoke flow line. The inner flow is directed to the ceiling of the flow facility where a screw injector is used for particle injection. The coaxial jet issues into the ambient fluid through concentric nozzles with coplanar exits. The inner flow is supplied from a 5-cm diameter plenum chamber exiting through a 6.45:1 area contraction aluminum nozzle with a 2-cm exit diameter. Depending upon the test conditions, the annular flow exits either from a circular or an elliptic nozzle of various exit dimensions. The jet plenum contains a loud speaker which can produce axial fluctuations in jet exit velocity with the fluctuation waveform specified by the laboratory computer.

In the first phase of the project elliptic coflow nozzles with top hat exit velocity profiles have been designed using computational fluid dynamics tools. Flows through annulus of fifth, fourth, and third degree polynomial outer wall and fifth order polynomial inner wall have been computed by solving compressible Navier-Stokes equation over three dimensional computational domains. The length of the fifth degree wall has also been varied to understand the effects of wall length. Initial results show that

the uniform exit velocity profile depends on the outer wall length. However different combinations of outer and inner wall profiles yield non-uniform velocity profiles at the exit of the nozzle. Stereo lithography system has been used to fabricate the nozzles.

The second phase of the project will investigate flow structures of co-flowing jets at different exit conditions. Flow visualization, hot wire anemometry and phase doppler anemometry (PDA) will be used as diagnostic tools. Pulsating laser based smoke flow visualization technique will be used to study the dominant coherent structures of the flow. More detailed measurements of both the particle and gas phase will be made using a hotwire anemometer, a three component LDV (for point measurement) and a PDA (particle concentration) system.

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List of Publications

1. Choudhuri, A. R., Vergas, A., and Wicker, R. B., ***A Numerical Investigation On Flow Through 2-D and 3-D Co-axial Nozzle Burners,*** ASME 2002 International Joint Power Generation Conference and Exhibts (IJPGCE 2002), *submitted*.

2. Choudhuri, A. R., Jasso, F., and Wicker, R. B., ***Characteristics of Elliptic Co-Axial Jet,*** 2002 Intersociety Energy Conversion Engineering Conference (IECEC 2002), *submitted*.

List of Theses

1. Fernando Jasso, MS; Thesis Title: ***Structures of Elliptic Coaxial Jet***; Expected Completion Date: December 2002.
2. Abel Vergas, MS; Thesis Title: ***A Numerical Investigation on Elliptic Coflow Gas Jet Flames***; Expected Completion Date: August 2002.

Students Receiving Support from the Grant

1. Mr. Fernando Jasso, Graduate Student

2. Mr. Ricardo Gallarzo, Undergraduate Student