Development of Criteria and Identification of Particle Cluster Size Based on Measurements of Void Fraction in Gas-Solid Systems

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Abstract

To predict the performance of Circulating Fluidized Bed (CFB)'s several computational fluid dynamics (CFD) codes have been developed to simulate the hydrodynamics, heat transfer, and chemical reactions in fluidized bed gasifiers and other power generation equipment where gas-solid flow is dominant. These computer codes are based on accepted equations governing multiphase flow. However, detailed information on gas-solids flow structure, especially identification of particle cluster size and solid concentration, is needed for validation of such CFD codes.

Objective

The objective of this research is to analyze granular temperatures of clusters of particles (6 or more particles) in order to determine the solids concentration where the granular temperature is a maximum for a given set of experimental conditions (particle size, particle density, etc.)
To achieve this we are performing experiments using a new particle shadow imaging technique to identify particle cluster size, measure void fraction in clusters and dispersed flow. This data is used to calculate the mean granular temperatures of clusters with different groupings of particles. These experiments are repeated from dilute to dense solids concentrations to identify the solids concentration (i.e., average void fraction) in the flow at which the granular temperature reaches its maximum.

Accomplishments to Date

The experimental setup was completed in March. The riser is 10 feet tall, 6 inches in diameter and made of clear acrylic. Spherical, glass particles with a mean diameter of 450 µm are used. Particles are fluidized with air supplied from the bottom of the flow loop. They are separated from the flow and collected while the air passes out through an opening in the top of the loop. At one point in the riser particles are illuminated from one side and the shadows of the particles are captured on the opposite side of the riser with a camera. The shadow particle sizing technique captures the particle shadows at any instant of time in a defined volume inside the riser. Experiments are performed in the riser and images of dispersed flow are obtained. The position of the solid particles and the solid and void volume fractions are obtained from the pictures. The depth of particles from the riser wall is obtained by analyzing the gradient in the intensity profile of the halo area around each particle's shadow. Over 100 static images of particles have been collected and analyzed for flows of 50 CFM.

Future Work

Using successive images from the shadow particle sizing technique, the velocities of the particles will be obtained. A compressor will be included into the loop to allow for increased particle concentrations and particle cluster sizes. Experimental data will be analyzed for various flow regimes (40 – 80 CFM).

Paper under this Research

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