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“Fluid Dynamics of Pressurized, Entrained Coal Gasifiers”

Technical Progress Report

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by

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1. Scope

Pressurized, entrained gasification is a promising new technology for the clean and efficient combustion of coal. Its principle is to operate a coal gasifier at a high inlet gas velocity to increase the inflow of reactants, and at an elevated pressure to raise the overall efficiency of the process. Unfortunately, because of the extraordinary difficulties involved in performing measurements in hot, pressurized, high-velocity pilot plants, its fluid dynamics are largely unknown. Thus the designer cannot predict with certainty crucial phenomena like erosion, heat transfer and solid capture.

In this context, we are conducting a study of the fluid dynamics of Pressurized Entrained Coal Gasifiers (PECGs). The idea is to simulate the flows in generic industrial PECGs using dimensional similitude. To this end, we employ a unique entrained gas-solid flow facility with the flexibility to recycle –rather than discard– gases other than air. By matching five dimensionless parameters, suspensions in mixtures of helium, carbon dioxide and sulfur hexafluoride simulate the effects of pressure and scale-up on the fluid dynamics of PECGs. Because it operates under cold, atmospheric conditions, the laboratory facility is ideal for detailed measurements.

These activities are conducted with Air Products & Chemicals, Inc., which is a member of a consortium that includes Foster Wheeler and Deutsche Babcock Energie- und Umwelttechnik AG. This consortium intends to develop and market Second Generation Pressurized Circulating Fluidized Bed (PCFB) technology.

2. Progress

In the second quarter of this project, we have continued our comparisons of the fluid dynamics of atmospheric and pressurized circulating fluidization. To this end, we have reproduced a series of experiments previously carried out in this group with plastic and glass powders fluidized by mixtures of helium and carbon dioxide (Chang & Louge,

1992). With this fluidization gas, the hydrodynamics of the suspension is analogous to that of a coal-burning atmospheric circulating fluidized bed.

Under these conditions, we have recorded radial profiles of particle volume fraction using an optical fiber probe. In order to calibrate the probe, we have compared its output with that of a "wall" capacitance probe, which provides a non-invasive, quantitative, time-dependent measure of the solid concentration at the wall of the riser. Details of the method are found in Lischer and Louge (1992).

In anticipation of our scale-up experiments for pressurized gasifiers, we have compared radial concentration profiles obtained with the glass and plastic powders, which simulate, respectively, the flows in atmospheric risers of 34 and 51cm (Figure 1). The agreement between the two sets of profiles further confirms that the dimensional analogy employed in this work is a valid tool for simulating the behavior of high velocity risers.

Fig. 1. Radial profiles of particle volume fraction. The circles, squares and triangles represent, respectively, the conditions in an analogous atmospheric combustor with $u=7\text{m/sec}$, $G=24\text{kg/m}^2\text{sec}$; $u=7\text{m/sec}$, $G=32\text{kg/m}^2\text{sec}$; $u=7\text{m/sec}$, $G=17\text{kg/m}^2\text{sec}$. The solid and open symbols are experiments with glass and plastic, respectively.

2. Next Research

In the next quarter, our objective is to begin simulating the conditions in a pressurized coal gasifier.

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