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Fluid Dynamics of Pressurized, Entrained Coal Gasifiers

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Disclaimer

Abstract

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.

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Progress

In the fifteenth quarter of this project, we have completed all experiments related to this project and have begun to correlate the results for "atmospheric" and "pressurized" flows. In particular, by comparing these results with those of earlier "pressurized" experiments at a different value of Ar, we have found that the parameter κ introduced in previous quarterly reports scales as

$$\kappa \approx 1.25 \; \frac{(1-\frac{1}{R}) \sqrt{R \; Ar}}{18 \; Fr} \; .$$

In this case, the gas voidage ε in the upper, nearly fully-developed region of a CFB riser, whether running under atmospheric or pressurized conditions, is reasonably predicted by the following Eq:

$$(1-\varepsilon)\,\varepsilon^2 = 1.25 \; [(\alpha-1) + (1-\varepsilon)(1+\frac{M}{R}) - \frac{M}{R}],$$

where $\alpha \approx 1.00035$ is a parameter expressing the correlation between the radial profiles of gas velocity and voidage, M is the solid loading and R is the solid-to-gas density ratio.

Our intention for the next quarter is to write the final report for this project.