Scaling of Pressurized Fluidized Beds

**Quarterly Report
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Overview

This report provides a summary of the technical progress made during the first quarter of the second budget period on Cooperative Agreement No. DE-FC21-92MC29264, "Scaling of Pressurized Fluidized Beds."

Technical Progress Report

● Selection of A Bed Material

Detailed analyses of the Tidd bed material were completed; parameters such as particle density, sphericity, average particle diameter, and size distribution were measured. The solid-to-gas density ratio (ρ_s/ρ_f) must be matched between the hot and the cold bed to achieve similarity. The Tidd bed material has a density of 2513 kg/m³. The gas density in the combustor is approximately 3.48 kg/m³ (1550 °F, 11 atm) giving a hot-bed density ratio of 722. Thus the cold bed, which will operate using ambient air, requires a bed material with a density of approximately 853 kg/m³. Linear low-density polyethylene has a density close to that required by the scaling laws ($\rho_s = 918$ kg/m³) and is commercially available in granular form. Similar analyses to those performed on the Tidd bed material were completed on samples of granular polyethylene.

The scaling laws also require that the ratio of superficial gas velocity to minimum fluidization velocity (u_o/u_{mf}) be matched between the hot and the cold beds. It is not possible to measure u_{mf} in the Tidd combustor directly; therefore a method had to be found to calculate it. Minimum fluidization velocity measurements were made on the Tidd bed material using ambient air. This data was used to screen different u_{mf} expressions to identify an expression that could be used to reliably predict u_{mf} in the Tidd combustor. The Ergun (1952) expression, which is the most widely used u_{mf} expression, did a poor job of predicting the u_{mf} data. Initially this raised questions over the accuracy of the measurements. After performing numerous checks on the experimental apparatus and repeats of the data, it was concluded that the Ergun expression was unsatisfactory for this application and that the measured u_{mf} was correct. The error in the Ergun equation prediction is most likely due to the broad size distribution of the Tidd bed material. The expression recommended by Grace (1982), which is of the same form as that originally proposed by Wen and Yu (1966), was found to predict the measured u_{mf} well. This expression was used to calculate the required cold bed particle diameter, based on the scaled cold bed u_{mf} , making it possible to choose a cold bed material. A linear low-density polyethylene produced by Union Carbide was chosen.

- Cold Scaled Model of Tidd Plant

Installation of the quarter-scale cold model of the Tidd pressurized bubbling bed combustor, in the MIT Heat Transfer Laboratory, is continuing. Difficulties in selecting a bed material slowed progress. The support structure for the bed has been constructed and the bed has been installed. Installation of items such as the cyclone, filter box, and instrumentation remain.

- Testing at Tidd

The Tidd plant tripped during the past quarter delaying testing until early in the next quarter. Current plans are to obtain pressure fluctuation data from Tidd at two bed levels during late January or early February.

Emphasis of Work During Next Quarter

Efforts during the second quarter of the second budget period will focus on:

- completing the installation of the Tidd cold scaled model in the MIT Heat Transfer Laboratory,
- obtaining pressure fluctuation data from the Tidd pressurized fluidized bed combustor, and
- making preliminary comparisons between the dynamic characteristics of the cold model and the Tidd pressurized bubbling fluidized bed combustor.

References

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Wen, C.Y. and Yu, Y.H., "A Generalized Method for Predicting the Minimum Fluidization Velocity," AIChE Journal, Vol. 12, No. 3, 1966, p. 610.

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