CHARACTERIZATION OF GAS PRESSURE FLUCTUATIONS FOR A PYROLYTIC CARBON REACTOR

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Introduction

Fluidized bed reactors are commonly used to deposit pyrolytic carbon onto substrates used for prosthetic heart valves. Previous work has shown that fluidized bed hydrodynamic behavior is important to forming densely packed coatings [1]. Likewise, previous work has identified pressure monitoring as an effective method for characterizing fluidized bed behavior [2]. The current work is an extension of these previous works in that the characterization of gas inlet pressure fluctuations under steady flow conditions is used to evaluate both the hydrodynamic behavior and the relative stability of a conical shaped fluidized bed reactor.

Experimental

Pressure data were obtained by installing a pressure transducer, with a response time of 1 ms, immediately prior to the reactor's gas inlet. The analog output signal was routed through a 10 Hz low pass RC filter and subsequently recorded using a PC based data acquisition system with a sampling rate of 36 Hz.

Time domain data was converted to frequency spectra using the FFT. Experimental averaging and data smoothing were employed to generate graphical results that illustrate gross differences between the experimental cases.

Process conditions for the experiments were a bed particle charge of 500 grams (300-400 micron particles), a total gas flow rate of 18 SLPM, and an operating temperature of 1350 C.

Results and Discussion

Nozzle orifices may be described by the ratio of inlet to outlet diameters (D_I / D_o) as shown in Figure 1. Frequency response curves for D_I / D_o ratios ranging from 1.0 to 0.15 are illustrated in Figure 2.

As one moves from a straight nozzle to a highly constricted nozzle, the mean and peak frequency response amplitudes were observed to decrease. Figure 3 depicts this trend for mean response values where decreasing amplitudes represent a reduction in the average bed particle energy. This change is believed to result in a more uniform fluidized bed that does not exhibit the unstable spouting phenomena commonly associated with this type of process.

Constricted nozzles may also be distinguished by principal frequency amplitude ratios. The amplitude ratio of the two primary frequencies was seen to increase with the degree on nozzle constriction (Figure 4). Higher ratios represent conditions where a dominant frequency exists, and this too is believed to result in more uniform fluidization for this type of process.

Conclusions

The frequency response of a fluidized bed reactor can be manipulated through the design of the inlet geometry. Further, optimal inlet design for a specific application can be achieved by studying the frequency response of the system.

References

[1] Hofmann, G., Wiedenmeier, M., Freund, M., and Beavan, A., Porosity Formation in Pyrolytic Carbon Coatings, Extended abstracts, 24th biennial conf. on carbon, Charleston (South Carolina, USA) American Carbon Society, 1999.

[2] Dhodapkar, S. and Llinzing, G., Pressure Fluctuation Analysis for a Fluidized Bed, AlChE Symposium Series, No. 296, Vol. 89, 170-183.

Acknowledgments

The authors wish to acknowledge the contributions of Richard Mangrum, Randy Weldy, and Cephas Wozencraft for devising several of the test cases, fabricating components, and performing the experimental work.

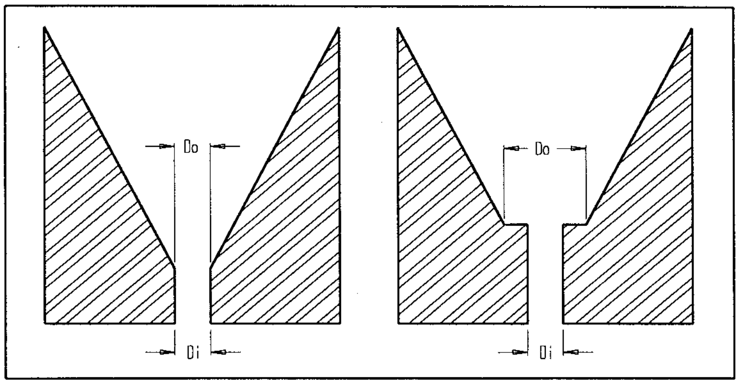

Figure 1. Nozzle designs: straight (D_I / D_o = 1.0) and constricting nozzles (D_I / D_o < 1.0)

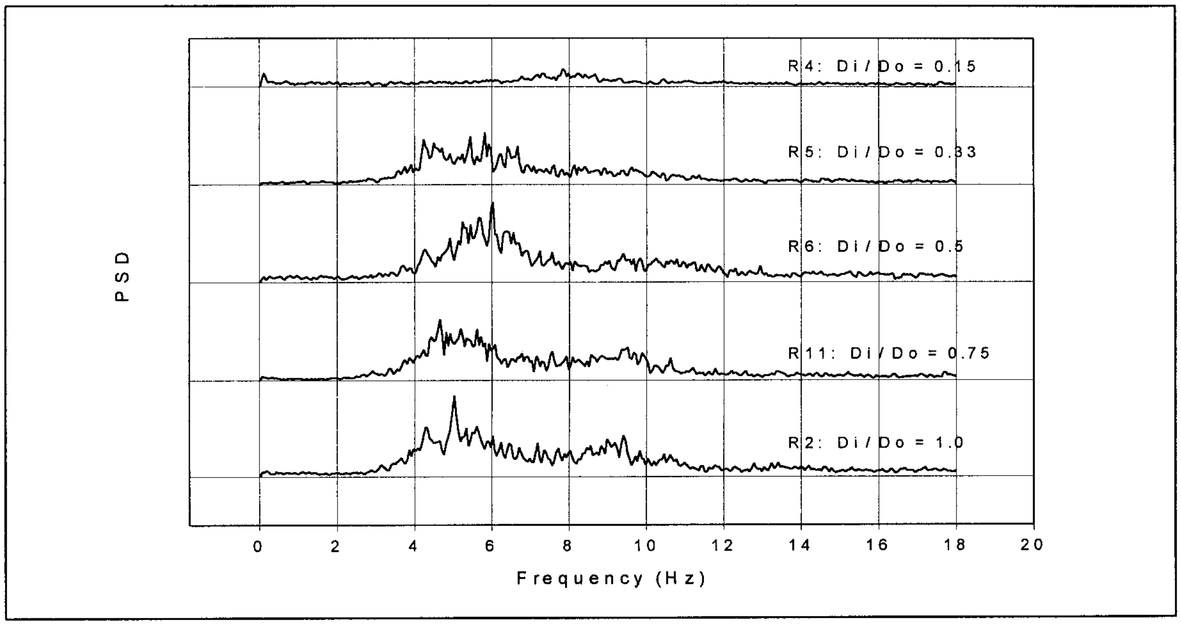

Figure 2. Comparison of power spectrums for several different D_i / D_o ratios.

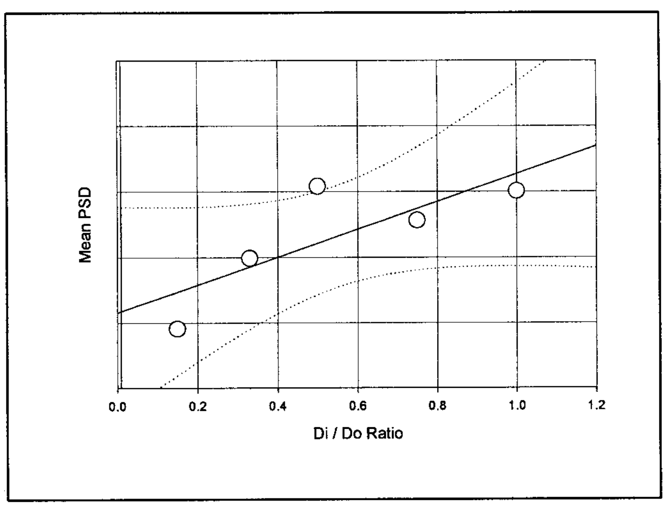

Figure 3. Mean amplitude versus D_I / D_o ratio.

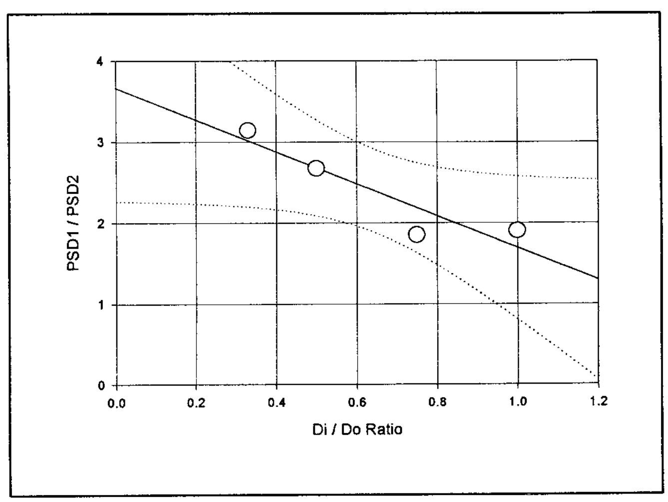

Figure 4. Amplitude ratio versus D_i / D_o ratio.