"The Scale-up of Large Pressurized Fluidized Beds for Advanced Coal-Fired Power Processes"

Technical Progress Report
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MIT

More refinement was added to the five sample ports that were installed along the cold model riser. Each sample port is now equipped with an electrically actuated $\frac{3}{8}$" ball-valve that can be operated from a switch in the main control panel area. These actuated ball valves control the on/off position of the sample port. They are switched on for a desired period of time for sample collection during a test run. They are particular useful for the hard-to-reach sampling locations near the top of the riser where manually operating a ball-valve could be difficult.

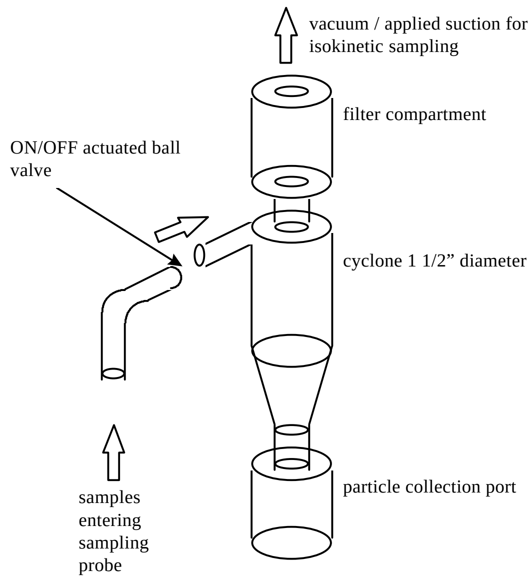
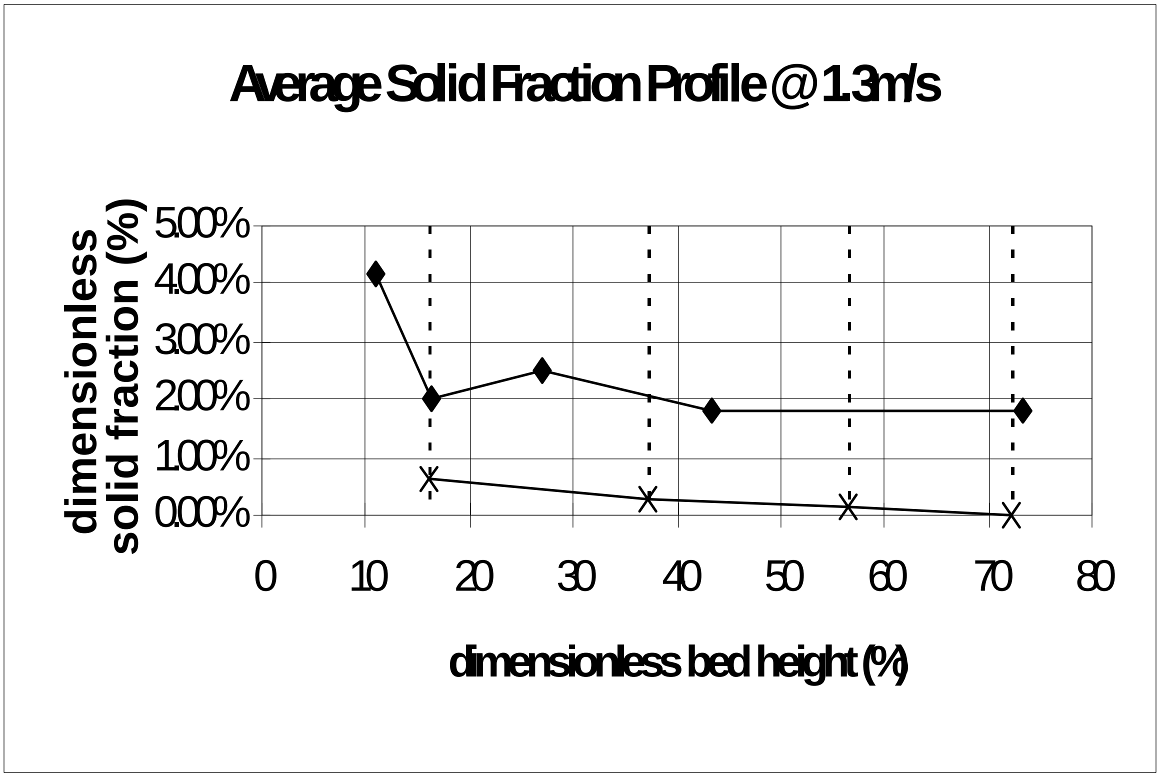


Figure 1 Sample Port

The confidence level of the pressure transducers signal has been accessed. Initial pressure readings indicated that the pressure drop (as measured by the pressure transducers) near the distributor is negative where a positive value is expected. Effort has been spent to look into the problem. It was found that the jet-like exit geometry of the distributor forms an acceleration zone where a certain distance away from the distributor is required for pressure recovery. An analytical model was developed to verify the negative pressure measurement based on the acceleration assumption. The model prediction results agree well with the measured pressure readings. The model was then used further to quantify the acceleration region distance, allowing a better understanding of the validity of pressure transducer location, especially near the distributor.

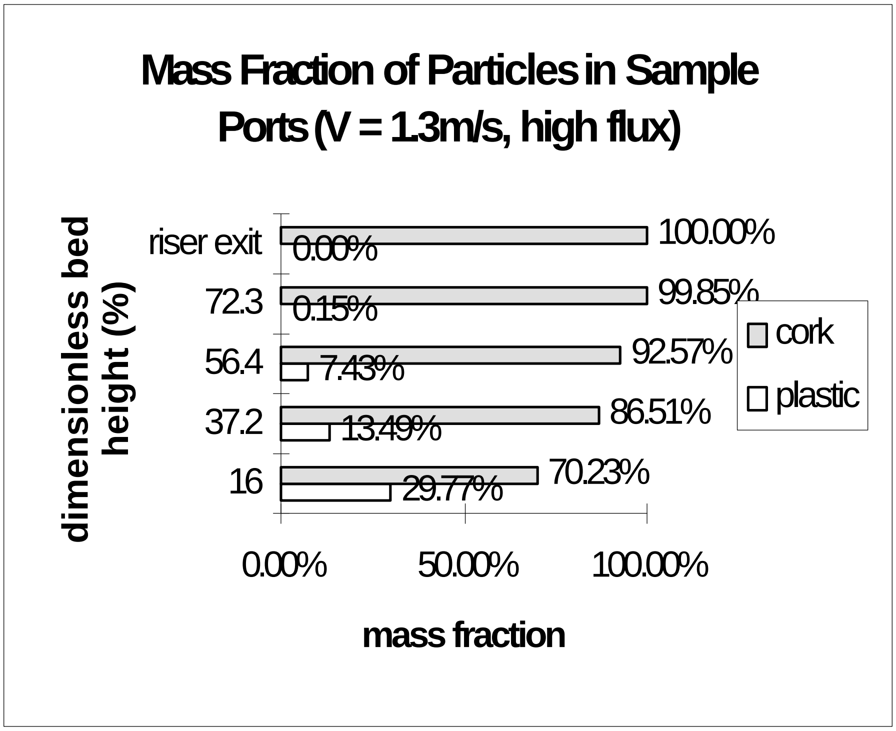
Initial results of mass solid fraction along the riser have been obtained for one specific case which is identical to that of Foster Wheeler Development Corp. The operating conditions for the MIT cold model are:

superficial gas velocity, u_o	= 1.3 m/s
solid recirculation rate, G_s	= 23.6 kg/m^2 s
solid composition (by mass)	= 25% plastic (simulating sorbent), 75% cork (simulating char)



where x denotes volume fraction of plastic (simulating sorbent) and • denotes volume fraction of both plastic and cork (cork simulates char)

Solid concentration of materials as determined by analyzing samples obtained from sample ports is as followed.



Mass Fraction of Particles in Sample Ports (V = 1.3m/s, high flux)
dimensionless bed height (%)
riser exit
72.3
56.4
37.2
16
100.00%
0.00%
99.85%
0.15%
92.57%
7.43%
86.51%
13.49%
70.23%
29.77%
cork
plastic
0.00%
50.00%
100.00%
mass fraction

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In the third semester of the project, we upgraded the facility with several new measurement techniques. First, we devised a reliable and inexpensive method to record the density of heavy gases held in the circulating fluid bed. Because SF6 breaks into corrosive species at high temperatures, its volume fraction cannot be evaluated with the thermal conductivity detector normally used for other inert gases. Instead, we now employ an MKS Baratron pressure gauge of 10 Torr full scale. By recording static pressure at two widely spaced elevations along the riser, we can check the overall density of the gas at rest. We validated the technique by extracting gas samples from the riser and measuring their composition using a gas chromatograph/mass spectrometer.

In addition, we designed and built a new capacitance/optical fiber probe system to record profiles of solid volume fraction across the riser. In this new system, light from a solid state laser is directly coupled into a "large-core coupler" consisting of two optical fibers fused together at a point. Light travels to the tip of the first fiber exposed to the solid suspension. Its fraction backscattered from the suspension then returns through the same fiber and jumps to the other fiber through the coupling. This technique greatly facilitates alignment of laser and detector. The detector's output is then calibrated against volume fraction recorded by the capacitance probe at the wall. To perform the calibration and subsequent measurements through the riser, we implemented a new LabView data acquisition system with associated hardware and software.

We also completed a series of experiments with glass beads fluidized with a mixture of SF6 and air. Although our original intention was to fluidize with pure SF6, we experienced difficulties in keeping it from leaking as well as drastic increases of its price on the open market. In this context, we tolerated small amounts of air contamination, which were monitored with the Baratron gauge. Despite these challenges, we managed to produce gas mixtures analogous to industrial pressurized circulating beds. In these experiments, the solid-to-gas density ratio, Archimedes number and ratio of bed to sphere diameter were 600, 360 and 2030, respectively. The operating Froude and loading were in the range 102 ¾ Fr ¾ 132 and 1.2 ¾ M ¾ 4.5, leading to cross-sectional average volume fractions in the range 0.3% to 1.9%. Finally, we recorded pressure drop across the primary cyclone and collected powder samples to evaluate cyclone efficiency during these experiments.

In the next semester, our plans are to carry out a next series of experiments with plastic powders. By comparing their results with those of the glass experiments, we will test the validity of the reduced scaling laws proposed by MIT.