SECTION 2: SUMMARY OF WORK PERFORMED

The dissolver cold-flow modelling studies were carried out in both 2-in.-i.d x 5-ft-high and 5-in.-i.d. x 5-ft-high Plexiglas columns. Apart from the diameter and column inlet arrangement differences, the experimental setups and test procedures for the two columns were identical.

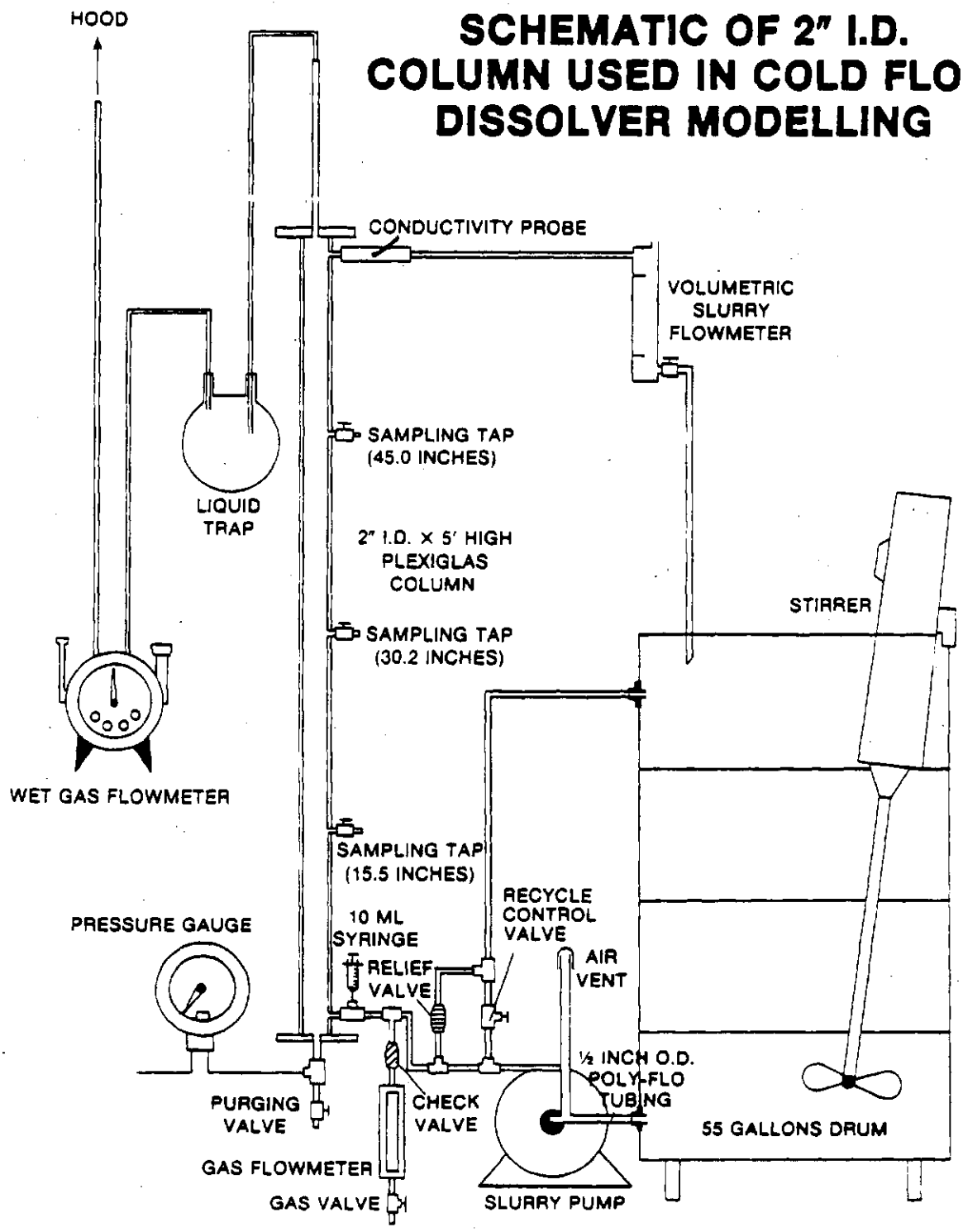
2-Inch-Diameter Column

A schematic of the 2-in.-diam column is shown in Figure 1. The slurry (or liquid) and gas were introduced simultaneously into the column through a 0.189-in.-diam orifice located on the column wall 1.5 in. from the bottom. A gas distributor was not used for this column. The slurry was allowed to flow upwards concurrently with the gas and to exit the column through a 0.189-in.-diam orifice located on the column wall 1.5 in. from the top. A conductivity probe was positioned at the slurry exit. Another orifice was provided at the top of the column so that the gas would not interfere with the conductivity readings. The liquid mixing was measured by the method of delta response using a NaCl solution as the tracer. Seven milliliters of 2.4-molar NaCl solution were introduced into the feed at an injection rate of 2.3 cm^3/sec. The effect of the injection rate was shown to be negligible in the range of 0.6 to 4.0 cm^3/sec.

After a steady concentration distribution of solids particles was established, samples of slurry were withdrawn through sampling taps into measuring cylinders. The weight of each sample was measured and solid particles were

FIGURE 1

SCHEMATIC OF 2" I.D. COLUMN USED IN COLD FLOW DISSOLVER MODELLING



then separated from the liquid, and dried and weighed. Imafuku (3) determined that the solids content of the withdrawn sample is the same as that of the slurry within the column. The samples were collected at intervals of 10 min.

To study the effect of feed location on concentration distribution, the above system was modified to feed both slurry and gas from the bottom of the column, as well as to separate the entrance of the phases.

For the simulation of the CPDU reactor, dimensional analysis was used to obtain flow patterns in the 2-in.-diam column that would be similar to that which may exit in the actual reactor. This was done by maintaining both the Reynolds and Froude numbers constant. This criterion was based on previous experience with flow systems, in addition to the difficulty related to the calculation of other dimensionless groups such as those containing liquid surface tension or solid-liquid wettability parameters. Using the operating parameters of the CPDU reactor and the physical properties of the two fluid systems, as summarized in Table 1, the slurry and gas flow rates (velocities) were established for the column simulator. Because the estimated slurry flow rate of 82 cm^3/min was too low to maintain in the experimental system for a reasonable period, most simulation experiments were carried out at slurry flows higher than 100 cm^3/min.

5-Inch-Diameter Column

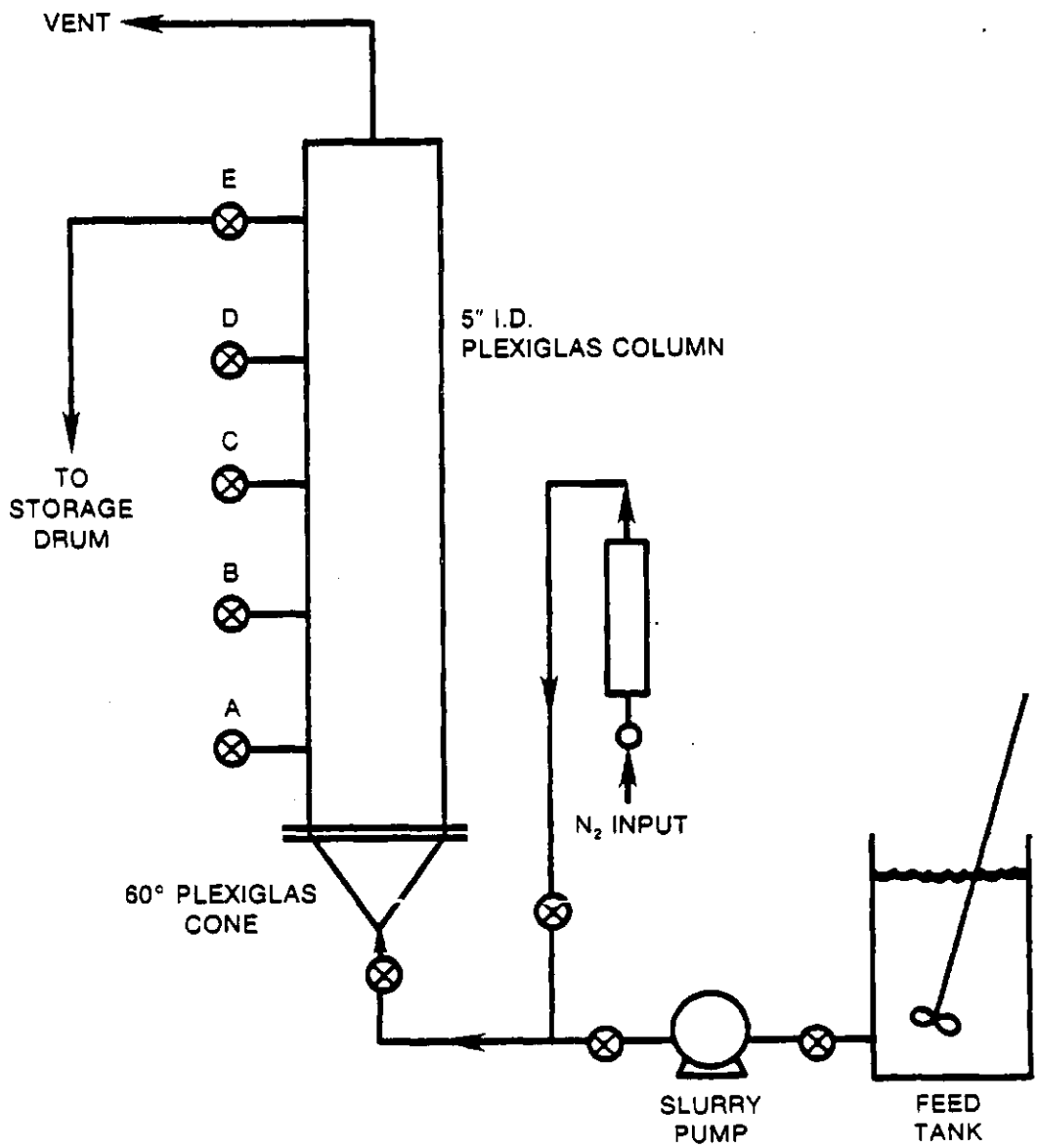
A schematic of the 5-in.-diam column is shown in Figure 2. Both the column and the conically shaped bottom inlet (60° angle with the horizontal) were fabricated from Plexiglas. The bottom was designed so that it would accept a

Table 1

Operating Parameters of the CPDU Reactor and Simulation Column

	CPDU Reactor Ash-solvent-hydrogen system		Simulation Column Silica-water-nitrogen system	
Liquid properties:				
Viscosity (μL)	0.74	$\frac{g}{cm\ min}$	0.60	$\frac{g}{cm\ min}$
Density (ρL)	0.86	$\frac{g}{cu\ cm}$	1.00	$\frac{g}{cu\ cm}$
Gas properties:				
Viscosity (μG)	0.012	$\frac{g}{cm\ min}$	0.011	$\frac{g}{cm\ min}$
Density (ρG)	0.048	$\frac{g}{cu\ cm}$	0.0011	$\frac{g}{cu\ cm}$
Solid properties:				
Particle diameter (dp)	0.015 cm		0.010 cm (140 mesh)	
Density (ρs)	2.40	$\frac{g}{cu\ cm}$	2.41	$\frac{g}{cu\ cm}$
Concentration (W)	0.04		0.04	
Slurry properties:				
Mean density (ρm)	0.90	$\frac{g}{cu\ cm}$	1.02	$\frac{g}{cu\ cm}$
Effective density (ρe)	1.54	$\frac{g}{cu\ cm}$	1.41	$\frac{g}{cu\ cm}$
Flow Velocities:				
Slurry (vM)	5.6	$\frac{cm}{min}$	4.0	$\frac{cm}{min}$
Gas (vG)	51.3	$\frac{cm}{min}$	37.0	$\frac{cm}{min}$
Residence time:				
Slurry ($\bar{t}$)	27.2 min		38.1 min	

FIGURE 2
SCHEMATIC OF 5-INCH DIAMETER PLEXIGLAS COLUMN



distributor plate. Five sampling taps (A-E) were located along the column. In typical operation, slurry exited through the topmost opening (E) and gas vented through the uppermost top central opening, which was similar to the 2-in.-diam column. A 10-cm^3 syringe was also attached to the column at the bottom in order to inject tracer into the feed stream for dispersion studies.

Gas Holdup

Gas holdup studies were performed extensively in both the 2- and 5-in.-diam columns. The effects of solids particles on gas holdup were measured both without and with fluid flow. In the absence of liquid flow, the column was completely filled with liquid and gas was then passed through it at a specified rate. Excess liquid exited the column at the top through the side opening. After a period of 10-15 min to ensure that a steady state was achieved, the bottom valve was closed to shut off the gas input. The final liquid level was measured, and the difference between the initial and final levels represented the gas holdup at that particular gas flow rate. Measurements were also made with a gas distributor plate with seven 0.25-in. openings inserted into the 5-in.-diam column. In addition, the entrance effect on gas holdup was determined using porous metal plates with 40-, 60- and 100-micron openings.

Both 30-45 mesh (600-350 μm) and -140 mesh (less than 100 μm) silica particles were employed to investigate the effect of solids suspension on gas holdup. To ensure a true solid suspension effect, a slightly modified technique was used. At the start of an experiment, the top exit opening was

valved off as gas passed through the column to allow complete solids suspension to develop. Then the valve was opened to empty any excess solution. The rest of the experiment proceeded as described above.

Continuous silica-water slurry flow experiments were also conducted. The slurry and nitrogen passed into the column through a centrally located opening at the bottom. After steady state was reached, a common valve at the bottom was closed, stopping both slurry and gas flow simultaneously. The gas void fraction was measured as described above.

Critical Gas Velocity

The critical gas velocity is defined as the minimum gas velocity required to produce a completely suspended slurry column. The critical velocity was determined by monitoring pressure drop versus the gas superficial velocity. When the solid particles are fully suspended, the pressure drop will be stabilized. These results were confirmed by observation of disappearance of settled solids. These experiments were carried out with a nitrogen-water-silica (140-mesh) system with various solid concentration levels ranging from 5.47 to 33.56 wt % . The critical gas velocity experiments were also carried out for larger size particles ranging from 80 to 20 mesh (177-841 μm) by dividing them into arbitrary particle size groups to study the effect of particle size on critical gas velocity.