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Engineering Developpment of Slurry Bubble Column Reactor ((SBCR) Technology

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ENGINEERING DEVELOOPMENT OF SLURRY BUBBLE COLUMN REACTOR (SBCR) TECHOLOGY

Quarteerly Technical Progress Report No. 11
for the I Period 1 October - 31 December 1997

Contract Objectives

The major technical objectives ofof this program are threefold: 1) to develop the design tools and a fundamental understanding of thee fluid dynamics of a slurry bubble column 0reactor to maximize reactor productivity, 2) to developp the mathematical reactor design models and gain an understanding of the hydrodynammic fundamentals under industrially relevant process conditions, and 3) to develop an understandiring of the hydrodynamics and their interaction with the chemistries occurring in the bubbble column reactor. Successful completion of these objectives will permit more efficient usage o of the reactor column and tighter design criteria, increase overall reactor efficiency, and ensure a dedesign that leads to stable reactor behavior when scaling up to large diameter reactors.

Summary of Progress

Task 2: Component Diagnosticics Development

Bubble Size Measurement

A probe system consisting of a duLual-tip probe and the computer code was developed to measure the bubble size distribution in a slslurry bubble column under high-pressure, high-temperature, and high-gas-velocity conditions. Thehe dual-tip probe was developed and discussed last quarter. A computer code was developed to p process the light intensity signals from a fiber optic probe. This computer code can calculate bothh the bubble rise velocity and the bubble chord length distribution from the signals.

A single example which shows thhe bubble column is in the slugging regime at a gas velocity of 34.6 cm/s and at 0.1 MPa pressurere is provided in this report. The computer code will be used to analyze the bubble size distributicon and operating regime in slurry bubble columns under high-pressure and high-gas-velocity coonditions.

Holdup Measurement with Solidds

A new technique for measuring ggas holdup in slurry bubble columns has been developed. The technique has two major advantagages: the elimination of uncertain particle density from the measurement and the capability toto determine if the particles are completely suspended.

One exciting aspect of both these e techniques is that they could be used to make measurements at LaPorte during runs as well as in n the laboratory.

(The Ohio State University)

Task 3: Model Selection and Development

Progress in Evaluation of the Momentum Balance Equation for Bubble Columns Using CARPT and CT Measurements

Rational model development involves selection of the forces that must be modeled. One way of determining the importance of these forces is to understand the effect of terms in the momentum balance equation. Last quarter we found that the addition of the turbulent drag force to the radial momentum balance improves the agreement for the case of high superficial gas velocity (12 cm/s in a 14-cm-diameter column). However, for the cases of low superficial gas velocity (4.8 cm/s), the agreement between the right-hand side (R.H.S.) and the left-hand side (L.H.S.) of the radial momentum balance deteriorated with addition of the turbulent drag force.

Possible sources of the observed discrepancies are evaluated and discussed. The holdup profile was found to have an important effect. The uncertainty of measuring the gas-liquid velocity correlations makes it difficult to determine the importance of these terms. Finally more velocity data are needed near the walls of the bubble column, since gradients are high in this region. This analysis continues.

(Washington University in St. Louis)

Task 4: SBCR Experimental Program

Effect of Pressure on Gas Holdup at Relatively High Pressures and with Solids

Gas holdup was measured in a slurry bubble column with a solids concentration of 20 wt % at 28°C and at various pressures using the new holdup measurement technique. The gas holdup increases with an increase in pressure. These measurements will be combined with bubble size measurements to obtain a good picture of flow in high-temperature, high-pressure bubble columns.

(The Ohio State University)

Turbulence Parameters in 18-in. Diameter Columns with and without Internals

The turbulence parameters (normal and shear stresses and kinetic energy) were evaluated from Computer Automated Radioactive Particle Tracking (CARPT) experiments performed at 2, 5 and 10 cm/s superficial gas velocities. These experiments were conducted with the air-drakeoil system in a 44.0-cm (18-in.) diameter column with and without internals. The internals consisted of 16 tubes of 1-inch diameter, which simulate the heat exchanger in the 18-in.-diameter column used in the Alternative Fuels Development Unit (AFDU) in LaPorte, Texas. A perforated plate distributor with hole diameter equal to 0.77 mm and open area equal to 0.076% was used. These data will allow us to begin to understand the effect of internals on flow patterns in reactors.

(Washington University in St. Louis)

Task 6 : Data Processing

Establishment of the Relationshhip between the Axial Dispersion Coefficient and Parameters of the Phenomenological Recycle n with Cross Flow and Eddy Diffusion Model

The axial dispersion model is simmple and relatively easy to use. However, a vital parameter, the dispersion coefficient, is difficultlt to obtain for scaleup. Our new model should give better scaleup information, but is relativively difficult to use. This new analysis allows the estimation of the dispersion parameter from an n equation that is more amenable to the estimation of scaleup performance.

A Taylor-type analysis of the twoo-dimensional convection-diffusion model for liquid mixing in a bubble column (which was develcloped and reported in the seventh and eighth quarterly reports) was performed to establish a relatationship between the axial dispersion coefficient and the parameters of this new phenomennologically based model. While the recycle with cross flow model describes the phenomena t that contribute to liquid mixing in a bubble column more reasonably than the axial dispersision model (ADM), the existence of only one parameter (the axial dispersion coefficient) makes the e ADM still attractive to many. Therefore, we have developed a procedure to estimate the axial didispersion coefficient from the parameters of the phenomenologically more correctct model.

(Washington University in St. Louis)