ENGINEERING DEVELOPMENT OF SLURRY BUBBLE COLUMN REACTOR (SBCR) TECHNOLOGY

Quarterly Technical Progress Report No. 6

For the Period 1 July - 30 September 1996

FINAL

Contractor

AIR PRODUCTS AND CHEMICALS, INC.
7201 Hamilton Blvd.
Allentown, PA 18195-1501

Bernard A. Toseland, Ph.D.
Program Manager and Principal Investigator

Richard E. Tischer, Ph.D.
Contracting Officer's Representative

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NOTE: THIS DOCUMENT HAS BEEN CLEARED OF PATENTABLE INFORMATION.

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Contract Objectives

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

Summary of Progress

Task 4: SBCR Experimental Program

The rise velocity of single bubbles is an important parameter in bubble columns; for example, it is often used in descriptions of holdup. The effect of temperature and pressure on this parameter was measured. In general the rise velocity increases with increasing temperature, but decreases with increasing pressure. The measured results were predicted well by the Fan-Tsuchiya equation for small bubbles and the Mendelson equation for large bubbles over a wide range of pressure (0.1-19 MPa) and temperature (27-78^{o}C). Note that the correct physical properties are needed for these equations; therefore, measurements made in the last quarters are important for establishing this relationship.

(The Ohio State University)

Measurements of the effect of pressure (0-15 MPa) on gas holdup were extended to gas flow rates as high as 30 cm/sec. As pressure increases in the bubble flow regime, transition to churn turbulent flow is delayed so that holdup changes significantly. In general, holdup increases with increasing gas flow rate. The rate of increase is much higher for the bubble flow regime than for the churn turbulent regime. In the transition region between flow regions, holdup can stay constant or even show a minimum with increasing flow rate. The minimum is more pronounced at intermediate pressure (3.5 MPa).

(The Ohio State University)

Changes in flow regime were identified with changes in the slope curve of the standard deviation of the pressure fluctuations plotted against velocity. If this correlation holds in larger columns, it will provide a method of understanding the transition in operating, industrial-scale columns.

(The Ohio State University)

Task 6: Data Processing

Radioactive tracer data from the previously conducted isobutanol to isobutylene AFDU run were re-analyzed using the methods and insight gained in the previous run. This analysis revealed that:

- An axial dispersion model can fit only data far from the injection point. This illustrates the approximate nature of this model and the need for a new design model.
- The liquid shows a high amount of backmixing. The dispersion coefficient increases with increasing flow rate, and the measured dispersion is about 50% higher than that obtained from standard correlations. The difference is likely due to the expansion of the gas in the reacting system and the higher pressure. However, some deviation can be attributed to the non-symmetrical injection technique.
- The gas tracer curves can be modeled well by the axial dispersion model. However, the mass transfer coefficients obtained from the model exhibit a large variance. The variance of the gas dispersion coefficient is lower. The gas dispersion is lower than predicted from existing correlations, but for this case, it is higher than that for methanol synthesis. Again the expansion of the gas in this case is the most likely cause of the higher dispersion.

(Washington University in St. Louis)

The Ohio State University Research

The following report from Ohio State University for the period July-September 1996 contains the following brief chapters:

1. LaPorte Unit vs High-Pressure/High-Temperature Bubble Column (Tasks 1 and 2)
2. Single Bubble Rise Velocity of N_2 in Paratherm NF Heat Transfer Fluid (Task 4)
3. Effect of Pressure, Temperature, and Gas Distributor on Bubble Column Hydrodynamics (Task 4)
4. References