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ENGINEERING DEVELOPMENT OF SLURRY BUBBLE COLUMN REACTOR (SBCR) TECHNOLOGY

FINAL

Quarterly Technical Progress Report No. 2

For the Period 1 July - 30 September 1995

Contractor

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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

- Specific statements of work have been received from both Ohio State University and Washington University in St. Louis.

- A hydrodynamics plant trial was conducted. A review of results from previous tests allowed improvements in techniques. Qualitative results show:
  - predominant liquid downflow at the reactor wall and upflow in the center
  - some liquid upflow at the wall and downflow in the center
  - fully developed profiles, which will allow modeling using the one-dimensional dispersion equation, for liquid tracer injections far from injectors
  - standard gas phase profiles with evidence of tracer solubility.

  Qualitative analysis of the results await data transmission from Tracerco.

  (Air Products and Chemicals)

- A review of measurement techniques for two- and three-phase flow was completed. A draft copy of the topical report is under comment at Air Products. As expected, the review points out the need for new measurement techniques. Adequate techniques for measuring two-phase flow under laboratory conditions are available. Techniques for measuring three-phase flows are limited. The report contains recommendations for the best techniques for the LaPorte operation, as well as a general review.

  (Washington University and Air Products and Chemicals)

- Experimental facilities have been modified at both universities:
  - The high-pressure, high-temperature column has been checked for safety.

Quartz windows on this column will be used for flow visualization.
- Pressure taps have been installed for dynamic gas disengagement measurements. A video camera for liquid level detection has also been installed.
- Wavelet filtering for improving the CARPT technique in identifying radioactive particle position and velocity was adapted for use in the present project. This technique was used to provide improved measurement of Reynolds shear stresses and turbulent energy in bubble columns.
- Methods for measuring particle motion as well as liquid motion by CARPT were considered.

(Washington University and Ohio State)

- A new phenomenological model, Recycle-Crossmixing with Dispersion Model (RCFDM), has been developed to overcome some of the shortcomings of the Axial Dispersion Model (ADM). This model accounts for convective recirculation within the liquid, as well as the dispersion accounted for by the ADM. CARPT-CT measurements can be used to provide estimates of the flow parameters for the model. Thus, in contrast to the ADM, the new model can also be used to model the flow structure revealed by the tracer experiments at LaPorte.

(Washingtom University)

- Techniques to measure liquid properties in a bubble column operating at high pressure and high temperature have been developed for surface tension, density and viscosity. Such *in situ* measurements are essential to the quantitative understanding of flow phenomena in operating bubble columns.

(Ohio State)

- Benchmarking the CFDLIB code for computational fluid dynamics continued. The major issue is the choice of a closure approximation for the interfacial momentum exchange terms in the averaged Navier-Stokes equations. Using drag, lift and virtual mass terms allows the simulation of circulation cells in a two-dimensional bubble column at least in a qualitative manner. Quantitative simulation and simulation of three-dimensional problems are the subjects of continuing work.

(Washingtom University)