

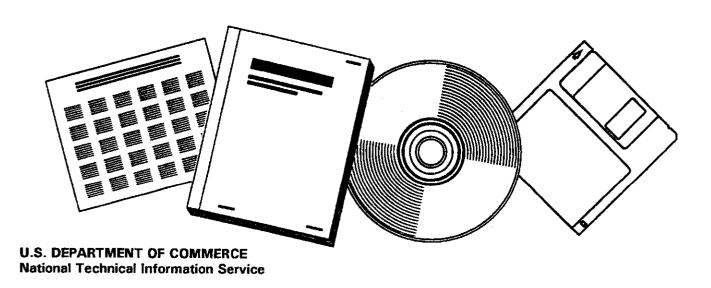
DE84013974



INTERNAL R AND D TASK SUMMARY REPORT: LARGE-SCALE DISSOLVER COLD-FLOW MODELING

INTERNATIONAL COAL REFINING CO. ALLENTOWN, PA

JUN 1984



DOE/OR/03054-20 (DE84013974) Distribution Category UC-89

INTERNAL R&D TASK SUMMARY REPORT: LARGE-SCALE DISSOLVER COLD-FLOW MODELING

By Samir F. Moujaes

June 1984

International Coal Refining Company Allentown, Pennsylvania

TABLE OF CONTENTS

| | Page |
|---|------|
| ABSTRACT | vii |
| EXECUTIVE SUMMARY | 1 |
| INTRODUCTION | 4 |
| Gas/Slurry Flow in Coal Liquefaction Processes (Fluid | 7 |
| Dynamics in a Three-Phase Flow Column) | |
| Large-Scale Dissolver Cold-Flow Modeling | 8 |
| Demonstration Plant Dissolver Design | 8 |
| EXPERIMENTAL RESULTS AND DISCUSSION | 9 |
| Gas Holdup | 9 |
| Effect of Column Diameter | 9 |
| Effect of Liquid Velocity | 9 |
| Effect of Gas Velocity | . 9 |
| Effect of Solids | 11 |
| Effect of Distributors (Entrance Effects) and Internals | 11 |
| Gas Holdup Correlations | 12 |
| Liquid Axial Dispersion Coefficient | 15 |
| Effect of Liquid Velocity | 15 |
| Effect of Gas Velocity | 19 |
| Effect of Solids | 19 |
| Effect of Internals | 19 |
| Liquid Axial Dispersion Coefficient Correlations | 19 |
| Gas/Liquid Mass-Transfer Coefficient | 21 |
| Solids Dispersion | 24 |
| Theoretical Background | 24 |
| Fine Particles | 25 |
| Large Particles | 31 |
| Continuous-Flow Solids Distribution | 32 |
| Solids Dispersion Modeling | 40 |
| Solids Withdrawal | 42 |
| SCALE-UP CONSIDERATIONS FOR THE DEMONSTRATION PLANT | 43 |
| LITERATURE CITED | 48 |
| FIGURES | 50 |
| NOMENCLATURE | 114 |
| APPENDIX A | 116 |

LIST OF TABLES

| Table No. | <u>Title</u> | Page |
|-----------|---|------|
| 1 | Physical Properties of Different Liquids | 10 |
| 2 | Correlations for Predicting Gas Holdup | 13 |
| 3 | Effect of Liquid Velocity on Axial Liquid Dispersion Coefficient in the Presence of Distributor No. 1 | 16 |
| 4 | Effect of Liquid Velocity on Axial Dispersion Coefficients in the Presence of Distributor No. 2 | 17 |
| 5 | Axial Liquid Dispersion Values (E _{ZL}) in a 50% Glycol Mixture with a 12-in. Column | 18 |
| 6 | Summary of V_p/E_{Zp} for Fine Particles as a Function of Gas Velocity | 27 |
| 7 | Summary of $V_{\rm p}/E_{\rm Zp}$ for Fine Particles as a Function of Column Diameter and Gas Velocity | 28 |
| 8 | Values of V_p/E_{Zp} for -140-Mesh Sand in Glycol/Water Mixtures | 29 |
| 9 | Values of V _p /E _{7p} for Fine Particles as a Function of Gas Velocity in a 12-inDiameter Column | 30 |
| 10 | Summary of $V_{\rm p}/E_{\rm Zp}$ for Large Particles as a Function of Gas Velocity | 33 |
| 11 | Summary of $V_{\rm p}/E_{\rm 7p}$ for Large Particles as a Function of Column Diameter and Gas Velocity | 34 |
| 12 | V _p /E _{7p} for 90 and 70% Glycol in 12-in. Column USing ^p 60/80-Mesh Sand | 35 |
| 13 | Summary of V_p/E_{Zp} for Large Particles as a Function of Gas Velocity | 36 |
| 14 | Summary of Effects of Liquid Properties on V ₂ /E ₂ for Large Particles in a 12-in. Diameter Column ² P | 37 |

LIST OF FIGURES

| FIGURE NO. | TITLE | PAGE |
|------------|---|------------|
| 1 | Effect of Column Diameter on Gas Holdup (Tetralin/Nitrogen) | 50 |
| 2 | Effect of Column Diameter on Gas Holdup (Water/Air) | 51 |
| 3 | Effect of Column Diameter on Gas Holdup (Air/Glycol) | 52 |
| 4 | Effect of Liquid Velocity on Gas Holdup (Air/Water) | 53 |
| 5 | Effect of Liquid Velocity on Gas Holdup (Tetralin/Nitrogen) | 54 |
| 6 | Effect of Gas Velocity on Gas Holdup (Air/Water) | 5 5 |
| 7 | Effect of Solids on Gas Holdup (Air/Water and Air/Water/Sand) | 55 |
| 8 | Effect of Solids on Gas Holdup (Nitrogen/Tetralin/Sand) | 57 |
| 9 | Effect of Distributor Plate on Gas Holdup in the Absence of Liquid Flow and Solid Phase | 58 |
| 10 | Effect of Distributor Plate on Gas Holdup at Low Liquid Velocity with High Concentration of Large Solid Particles | 59 |
| 11 | Effect of Distributor Plate on Gas Holdup at High Liquid Velocity with Low Concentration of Large Solid Particles | 60 |
| 12 | Effect of Distributor Plate on Gas Holdup at Low Liquid Velocity with No Solids | 51 |
| 13 | Effect of Distributor Plate on Gas Holdup at High Liquid Velocity with Low Concentration of Fine Particles | 62 |
| 14 | Effect of Distributor Plate on Gas Holdup at Low Liquid Velocity with High Concentration of Fine Particles | 53 |

| FIGURE NO. | TITLE | <u>PAGE</u> |
|------------|---|-------------|
| 15 | Effect of Different Internals on Gas Holdup | 64 |
| 16 | Comparison of Hughmark's, Pilhofer's, and Akita and Yoshida's Correlations for the Data from 5- and 12-inch Columns (Tetralin/Nitrogen) | 65 |
| 17 | Comparison of Correlations with Experimental Data (100% Glycol) | 66 |
| 18 | Comparison of Correlations with Experimental Data (90% Glycol) | 67 |
| 19 | Comparison of Correlations with Experimental Data (70% Glycol) | 68 |
| 20. | Comparison of Correlations with Experimental Data (50% Glycol) | 69 |
| 21 | Variation of Gas Holdup at Elevated Pressures | 70 |
| 22 | Gas Holdup in Exxon Donor Solvent Reactors from Tracer Data | 71 |
| 23 | Log/Log Plot of Liquid Axial Dispersion Coefficient vs. Gas Velocity (Air/Water) | 72 |
| 24 | Effect of Gas Velocity on Axial Liquid Dispersion Coefficient (Tetralin/Nitrogen) | 73 |
| 25 | Comparison of E _{7L} for Batch and Continuous Experiments (50% Glycol/Air) | 74 |
| 26 | Axial Liquid Dispersion Coefficients vs. Gas Velocity | 75 |
| 27 | Plots of E _{ZL} (Experimental and Correlation) vs. Superficial Gas Velocity for the 12-in. and 6-ft. Columns | 76 |
| 28 | Effect of Solids on Gas/Liquid Mass-Transfer Coefficients (Air/Water and Air/Water/Sand) | 77 |
| 29 | Effect of Distributors on Gas/Liquid Mass Transfer | 78 |
| 30 | Effect of Varying Gas Velocity through Spargers on Gas/Liquid Volumetric Mass-Transfer Coefficient in a 6-ft Column | 79 |
| 31 | Effect of Different Internals on Gas/Liquid Volu- metric Mass-Transfer Coefficient in a 6-ft Column | 80 |

| FIGURE NO. | TITLE | PAGE |
|------------|--|------|
| 32 | Effect of Solids on Gas/Liquid Volumetric Mass Transfer Coefficient | 81 |
| 33 | Effect of Gas Velocity on Concentration vs. Length in a 5-in. Column | 82 |
| 34 | Effect of Gas Velocity on Concentration vs. Length in a 12-in. Column (Tetralin/-140 Mesh Sand) | 83 |
| 35 | Effect of Gas Velocity on Concentration vs. Length in a 12-in. Column (Glycol/-140-Mesh Sand) | 84 |
| 36 | Effect of Gas Velocity on Concentration vs. Length in a 5-in. Column (Tetralin/60-70 Mesh Glass Beads) | 85 |
| 37 | Effect of Gas Velocity on Concentration vs. Length in a 12-in. Column (Tetralin/60-80 Mesh Sand) | 86 |
| 38 | Effect of Gas Velocity on Solids Distribution Con- centration vs. Axial Length (Glycol/60-80 Mesh Sand) | 87 |
| 39 | Effect of Gas Velocity on Concentration vs. Length in a 12-in. Column (Tetralin/-140 Mesh Sand) | 88 |
| 40 | Effect of Gas Velocity on Solids Distribution Profile in the 12-in. Column (Glycol/-140 Mesh Sand) | 89 |
| 41 | Effect of Gas Velocity on the Distribution of Large Particles | 90 |
| 42 | Effect of Gas Velocity on Concentration vs. Length in the 12-in. Column | 91 |
| 43 | Effect of Gas Velocity on Average Solids Distribution | 92 |
| 44 | Effect of Gas Velocity on Solids Distribution (6-ft Column; 100-200-Mesh Sand; Continuous Mode) | 93 |
| 45 | Effect of Gas Velocity on Solids Distribution (6-ft Column; 100-200- and 30-50-Mesh Sand; Continuous Mode) | 94 |
| 46 | Effect of Liquid Velocity on Solids Distribution | 95 |
| 47 | Effect of Liquid Velocity on Axial Solids Distri- bution | 96 |
| 48 | Effect of Liquid Velocity on the Distribution of Fine Particles | 97 |

| FIGURE NO. | TITLE | PAGE |
|------------|--|------|
| 49 | Effect of Liquid Velocity on Axial Solids Distribution (100-200-Mesh | 98 |
| 50 | Effect of Liquid Velocity on Axial Solids Distri- bution (100-200- and 30-50-Mesh) | 99 |
| 51 | Effect of Liquid Velocity on Solids Accumulation | 100 |
| 52 | Effect of Viscosity on Solids Distribution | 101 |
| 53 | Effect of Particle Size on Solids Distribution (5~in. Column/ Continuous Mode) | 102 |
| 54 | Effect of Particle Size on Solids Distribution (12-in. Column; Continuous Mode) | 103 |
| 55 | Effect of Particle Size on Solids Distribution (6-ft Column; Continuous Mode) | 104 |
| 56 | Effect of Distributors on Normalized Solids Distribution | 105 |
| 57 | Effect of Distributors on Nondimensionalized Solids Distribution (12-in Column; 60-80-Mesh Sand) | 106 |
| 58 | Effect of Column Diameter on Nondimensionalized Solids Distribution | 107 |
| 59 | Effect of Column Diameter on Solids Concentration (No Distributor) | 108 |
| 60 | Effect of Column Diameter on Solids Concentration (Distributor #1) | 109 |
| 61 | Slurry Concentration vs. Axial Length: Comparison with Model's Predictions (Water/Sand) | 110 |
| 62 | Slurry Concentration vs. Axial Length: Comparison with Model's Predictions (Tetralin/Sand) | 111 |
| 63 | Slurry Concentration vs. Axial Length: Comparison with Model's Predictions (50% Glycol/Sand) | 112 |
| 64 | Effect of Large Particles on Solids Removal | 113 |