



Solid-Liquid Separation for Liquefied Coal Industries

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Solid-Liquid Separation for Liquefied Coal Industries

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ABSTRACT

This book has been written for engineers concerned with separation processes related to liquefied coal slurries. Difficulties in removing mineral residues and unconverted carbon represent a major obstacle to economic production of liquefied coal products. Reactor slurries in which hydrogenation has been used to upgrade coal generally contain 5-10 weight percents of solids which must be removed. Various kinds of equipment employed for particulate removal include rotary drum pressure, candle, and leaf filters, solid bowl centrifuges, hydrocyclones, and critical solvent de-ashers.

Although emphasis has been given to filtration of solvent refined coal, much of the material is of a fundamental character and is applicable to other fields. Analysis of filtration data requires an understanding of the principles of frictional flow through compressible beds of particulates. Much of the analysis appearing in the literature must be carefully evaluated as errors and misinterpretations abound.

EPRI PERSPECTIVE

PROJECT DESCRIPTION

One of the major problems in coal liquefaction processes is how to separate solids, mineral matter, and unconverted coal from liquefaction products. A study and survey were made of various solid-liquid separation (SLS) schemes used in process development since 1970. A general background to solid separation technology was sought to produce a well-rounded treatise on the technology and to provide a useful guide for the technical community. Filtration of solvent-refined coal (SRC) was emphasized, although much of the research material is of a fundamental character and is applicable to other fields.

PROJECT OBJECTIVES

The primary objective of this project (RP1411-1) was to search for, review, and evaluate SLS technology developments in coal liquefaction processes. A second important objective was to critically analyze selected experimental data, since current methodology is not always applied. Other objectives were to significantly emphasize filtration of SRC liquids and to supply methodology generally applicable to filtration.

PROJECT RESULTS

Most of the significant coal liquefaction process development efforts in the United States, the United Kingdom, and the Federal Republic of Germany are referred to in this work. Many approaches to the solid separation problem were investigated and the results were critically analyzed. A general background to SLS was developed. Solid separation as a division of particle technology and dependence on particle science was discussed. Equipment and processes utilized in pertinent liquefaction applications were discussed in the context of the current technology. Particle-characterization methods and particle-size distributions of liquefied coal slurries were explored. Interfacial phenomena of particles in coal-derived liquids were considered. Flow

through porous media related to cake filtration was thoroughly developed. The application of classical filtration behavior analyses and preferred analyses was suggested. Extensive data from the Wilsonville SRC pilot plant were analyzed and interpreted, and application of the Wilsonville experience was projected.

The final report supplies an authoritative treatment of SLS technology as it relates to coal liquefaction. The book contains ample references for each chapter, significant papers, articles, literature reviews, and selected abstracts.

Norman C. Stewart, Project Manager
Advanced Power Systems Division

SUMMARY

Following an introduction in Chapter 1, a general background to solid-liquid separation (SLS) is developed in Chapter 2. The position of SLS as a division of particle technology is discussed. Particle technology is shown to depend upon particle science which has the major subdivisions of particle categorization and surface chemistry or interfacial phenomena. SLS is divided into four major areas of (1) pretreatment, (2) thickening, (3) separation, and (4) post-treatment. Chemical and physical pretreatment operations are employed to increase particle size and to simplify subsequent operations. Gravity or centrifugal thickening removes a large fraction of the liquid prior to the more expensive filtration and centrifugation. Post-treatment is involved with filtrate clarification and washing and deliquoring of cakes.

Equipment and processes utilized in separation of ash and char from liquefied coal are discussed in Chapter 2.

Particle characterization is the subject of Chapter 3. Coal macerals and asphaltenes are discussed as they relate to liquefaction. Analyses of particle size distribution of liquefied coal slurries using the Coulter Counter, microscreens, sedimentation techniques, and the scanning electron microscope are compared.

Joseph Henry, Jr. contributed Chapter 4 which deals with interfacial phenomena of particles in coal derived liquids.

Basic principles of flow through porous media constitute the subject of Chapter 5. Parameters involved in porous media and Darcy's law provide the background for the chapter. The concept of drag or effective pressure is developed. Drag forces cause rearrangement of

particles in porous beds. Behavior is classified in accord with cake compressibility which is broken down into (1) incompressible, (2) moderately compressible (kaolin, liquefied coal solids), or (3) highly compressible (colloidal silica, flocculated waste water). Concepts of permeability and specific flow resistance are introduced.

In Chapter 6, the principles of Chapter 5 are used to develop formulas for cake filtration. Porosity and liquid pressure variations as a function of distance are derived. Volume vs. time relations for constant pressure, constant rate, and centrifugal pump filtration the heart of this chapter. Classical methods for analyzing filtration behavior are shown to be in error. Preferred methods of analysis are introduced.

Chapter 7 deals with the analysis of data taken during the filtration of liquefied coal. Data coming from the Wilsonville SRC plant indicate that clogging of both cake and medium by fine migrating particles is of major importance. Chapter 8 deals with continuous, rotary drum filtration. Cycle analysis is the subject of Chapter 9. Experimental equipment used for laboratory studies of filtration characteristics of liquefied coal slurries is covered in Chapter 10. The appendix is devoted to summaries and comments on representative articles which have appeared in the literature.

CONTENTS

	<u>Page</u>
CHAPTER 1 INTRODUCTION	1
1. SCOPE	1
2. SOLID-LIQUID SEPARATION	2
3. REFERENCES	4
CHAPTER 2 SOLID-LIQUID SEPARATION -- GENERAL BACKGROUND	5
1. SOLID-FLUID SEPARATION	5
2. CLASSIFICATION OF SLS OPERATION	6
3. STAGES OF SLS	8
4. RELATIVE AMOUNTS OF LIQUID REMOVED	9
5. EQUIPMENT COMBINATIONS	10
6. EQUIPMENT	11
7. SELECTION OF SLS EQUIPMENT	14
(1) Specifications	18
(2) Comparative Performance Profiles	19
(3) Rate of Cake Buildup	21
8. BED POROSITY AND MASS VS. VOLUME FRACTION	22
9. DECISION NETWORK	26
10. PRETREATMENT	27
11. SCALE-UP	29
12. SOLID-LIQUID SEPARATION OF LIQUEFIED COAL SLURRIES	30
13. FILTER AIDS	36
14. WILSONVILLE SRC PLANT	38
(1) Coal Slurry Preparation	39
(2) Coal Slurry Heating and Dissolution	39
(3) Filter Feed Preparation	40
(4) Filtration	40
(5) Mineral Residue Processing	43
(6) Wilsonville Separation Projects	43
15. EQUIPMENT USED IN SLS OF LIQUEFIED COAL IN WILSONVILLE	43
(1) Pressure Vessel (Tank) Filters	43
(2) Processing in the Pressure Vessel Filters	45

	<u>Page</u>
(3) Filter Aids Used at Wilsonville	46
(4) Pumping and Washing	46
(5) Centrifuges	47
(6) Critical Solvent De-ashing	48
16. COAL DIGESTION AND FILTRATION	49
17. ROTARY DRUM PRECOAT FILTRATION	49
18. HYDROCYCLONE	53
19. ANTI-SOLVENT DEASPHALTER	54
20. REFERENCES	55
21. NOMENCLATURE	58
CHAPTER 3 PARTICLE CHARACTERIZATION	59
1. ORIGIN OF PARTICULATES	59
2. PROPERTIES OF PARTICULATES	60
3. LIQUEFIED COAL SLURRIES	62
4. CLASSIFICATION AND ANALYSIS	62
5. AGGREGATES VS. INDIVIDUAL PARTICLES	67
(1) Definition of a Particle	69
(2) Particle Shape	69
(3) Particle Size Distribution	70
6. PARTICLE SIZE	71
7. EQUIVALENT SPHERICAL DIAMETER	73
8. PARTICULATE BEDS	76
9. PARTICLE PROPERTY ANALYSES	79
10. INDIRECT PARTICLE PROPERTY MEASUREMENT	82
11. MULTIPLE ANALYSES	83
12. PARTICLE SIZE ANALYSES OF LIQUEFIED COAL SOLIDS	97
13. HOUSTON, PENNSYLVANIA STATE, AND JOHNS-MANVILLE ANALYSES .	101
14. JOHNS-MANVILLE, AUBURN ANALYSES	102
15. REFERENCES	105
16. NOMENCLATURE	107
CHAPTER 4 INTERFACIAL PHENOMENA	108
1. INTRODUCTION	108
2. BACKGROUND	109
(1) Particle Characteristics	109
(2) Conventional Processes	110
3. A SEPARATION TECHNIQUE INVOLVING ANTI-SOLVENT AGGLOMERATION AND SEDIMENTATION	111
(1) Measurement of Particle Settling Rates	112

	<u>Page</u>
a. Direct Measurement Techniques	112
b. Indirect Measurement Techniques	115
(2) Influence of Process Parameters on the Settling Rate .	115
a. Influence of Temperature	115
b. Effect of Mixing	116
(a) Effect of mixing time at constant mixing speed	117
(b) Effect of mixing speed at constant mixing Time	120
(c) Influence of sequential mixing	123
(d) Modeling of unsteady state sequential mixing .	123
(e) Effect of sequential anti-solvent addition ...	125
(f) Process implications	126
c. Influence of Anti-Solvent Type	126
d. Mixed Anti-Solvents.....	131
e. Influence of Anti-Solvent Concentration	131
(3) Commercial Deashing Units	132
(4) Summary	133
4. SEPARATION TECHNIQUES INVOLVING PARTICLE SURFACE CHARACTERISTICS	133
(1) Regimes of Separation	134
(2) Liquid-Liquid Interfacial Collection	138
a. Experimental System	138
b. Effect of Surfactant Concentration	140
c. Aqueous Phase pH	140
d. Sequential Water Addition	141
e. Discussion	141
(3) Particle Transfer to Aqueous Phase	143
a. Fate of the Surfactant	143
b. Aqueous Phase pH	145
(4) Gas-Liquid Interfacial Collection	145
a. Experimental System	146
b. Oil Phase Composition	146
c. Oil Phase Temperature	146
d. Solids Type	148
e. Solids Size	150
f. Discussion	150
(5) Summary	150
5. REFERENCES	151
6. NOMENCLATURE	154

	<u>Page</u>
CHAPTER 5 FLOW THROUGH POROUS MEDIA	156
1. HISTORICAL BACKGROUND	156
2. POROUS MEDIA PARAMETERS	157
3. EFFECTIVE OR COMPRESSIVE DRAG PRESSURE	159
4. FLOW THROUGH COMPRESSIBLE POROUS MEDIA	164
5. MODIFIED DARCY EQUATION	167
6. CALCULATION OF ALPHA	168
7. DIMENSIONS OF FILTRATION RESISTANCE	171
8. CAKE STRUCTURE AND PARTICULATE DEPOSITION	172
9. MEDIUM RESISTANCE	178
10. POROSITY	181
11. RESISTANCE COMPRESSIBILITY COEFFICIENT	185
12. ANALYTICAL EXPRESSIONS FOR α , ϵ , $1-\epsilon$	187
13. AVERAGE SPECIFIC RESISTANCE	191
14. EFFECT OF SLURRY CONCENTRATION ON AVERAGE SPECIFIC RESISTANCE	195
15. REFERENCES	197
16. NOMENCLATURE	198
CHAPTER 6 FILTRATION	199
1. CAKE AND DEPTH FILTRATION AND CENTRIFUGATION	199
2. APPROACH TO FILTER THEORY	199
3. POROSITY VARIATION IN A FILTER CAKE	200
4. AVERAGE POROSITY	207
5. PUMPING MECHANISM	211
6. CONVENTIONAL FILTRATION EQUATIONS.....	214
7. MATERIAL BALANCES	215
8. VARIABLE INTERNAL FLOW RATE	216
9. AREA GROWTH IN LEAF FILTERS	219
10. DIFFERENTIAL EQUATION FOR CAKE FILTRATION	220
11. PRESSURE DROP ACROSS CAKE	224
12. CONSTANT PRESSURE FILTRATION	226
13. RESISTANCE FORM OF EQUATIONS	229
14. REVISED ANALYSIS OF CONSTANT PRESSURE FILTRATION	231
15. CONSTANT RATE FILTRATION	236
16. CENTRIFUGAL PUMP FILTRATION	237
17. REFERENCES	240
18. NOMENCLATURE	241
CHAPTER 7 DATA ANALYSIS	242
1. RATIONALE FOR OBTAINING DATA	242

	<u>Page</u>
2. PROBLEMS OF DATA ANALYSIS	242
3. TYPES OF DATA	244
4. METHODS OF TESTING	246
5. CONSTANT PRESSURE FILTRATION	248
(1) Classical Constant Pressure Analysis	251
(2) Revised Constant Pressure Analysis	253
6. LIQUEFIED COAL FILTRATION	259
(1) One to Three Point Analyses	260
(2) Variation of Specific Cake Resistance with Pressure Drop	266
(3) Wilsonville Filtration Data	271
(4) Clogging Theory	273
(5) Analysis of Wilsonville Filtration Data	278
(6) Medium and Cake Clogging	291
7. REFERENCES	295
8. NOMENCLATURE	296
CHAPTER 8 CONTINUOUS FILTRATION -- ROTARY DRUM FILTRATION	297
1. CONTINUOUS CAKE FILTERS	297
2. CONTINUOUS PRECOAT FILTERS	301
3. CONTINUOUS PRESSURE FILTRATION	304
4. DESIGN OF CONTINUOUS FILTERS	305
(1) Cake Mass and Formation Time	305
(2) Cake Washing	308
(3) Cake-Moisture Content, Gas Rate	309
(4) Filter Cycles	311
5. PRECOAT FILTRATION WITH A PRESSURE ROTARY DRUM FILTER	316
6. SELECTED RESULTS FROM THE JOHNS-MANVILLE REPORT	316
(1) Experimental Procedure	317
(2) Effect of Temperature on Filtration	317
(3) Effect of Differential Pressure on Filtration Rate ...	318
(4) Effect of Drum Speed on Rate	321
(5) Effect of Knife Advance on Rate of Precoat Consumption	322
(6) Effect of Precoat Grades on Rate	323
7. COMMENTARY ON THE JOHNS-MANVILLE REPORT	325
8. THEORETICAL CONSIDERATION	326
9. ESTIMATED VALUES FOR PARAMETERS	327
10. SPECIFIC FILTRATION RESISTANCE OF WILSONVILLE FILTER FEED (WFF)	328

	<u>Page</u>
11. SPECIFIC FILTRATION RESISTANCE OF TACOMA FILTER FEED (TFF)	330
12. REFERENCES	333
13. NOMENCLATURE	334
CHAPTER 9 CYCLE ANALYSIS	335
1. CYCLICAL PROCESSES	335
2. ELEMENTS IN BATCH FILTER CYCLES	335
3. LIQUEFIED COAL CYCLE RATES	337
4. CAKE WASHING TIME	339
5. CYCLE ANALYSIS FOR A SIMPLIFIED CASE OF CONSTANT PRESSURE FILTRATION	340
6. GENERALIZED CYCLE ANALYSIS FOR CONSTANT PRESSURE FILTRATION	342
7. CYCLE ANALYSIS FOR CONSTANT RATE FILTRATION	343
8. CYCLE ANALYSIS FOR CENTRIFUGAL PUMP FILTRATION	345
9. IMPROVEMENTS OF LIQUEFIED COAL FILTRATION CYCLE	345
10. FILTER AID FILTRATION OF LIQUEFIED COAL	347
11. AVERAGE CYCLE RATE FOR CONSTANT PRESSURE FILTRATION WITH FIXED CAKE GROWING SPACE	348
12. COMPOSITION AND TRUE SOLID DENSITY OF A BINARY MIXTURE ...	349
13. AVERAGE SPECIFIC FLOW RESISTANCE AND POROSITY	351
14. SUMMARY OF EQUATIONS FOR MAXIMIZING AVERAGE CYCLE RATE IN FILTER AID FILTRATION	352
15. POSSIBLE IMPROVEMENTS IN CYCLES	360
16. REFERENCES	363
17. NOMENCLATURE	364
CHAPTER 10 EXPERIMENTAL EQUIPMENT	369
1. SUMMARY	369
2. HIGH GRADIENT MAGNETIC SEPARATOR AT AUBURN UNIVERSITY	369
a. Principle	369
b. Equipment	370
c. Results and Conclusions	372
3. SOLID-LIQUID SEPARATION FOR H-COAL PROCESS DEVELOPED AT HYDROCARBON RESEARCH, INC.	372
(1) Summary	372
(2) Solvent Precipitation	373
(3) Horizontal Scroll Centrifuge	376
a. Equipment	376
b. Results and Conculsions	378
(4) Vertical Scroll Centrifuge	378

	<u>Page</u>
(5) Disc-Nozzle Centrifuge	380
(6) Magnetic Separation	382
(7) Pressure Precoat Drum Filter	382
(8) Batch Plate Filter	382
4. PRESSURE LEAF FILTERS DEVELOPED AT JOHNS-MANVILLE SALES CORPORATION	384
(1) Pressure Leaf Filter	384
a. Equipment	384
b. Results and Conclusions	386
(2) Rotary Pressure Leaf Filter	387
a. Equipment	387
b. Results and Conclusions	388
5. FILTER DEVELOPED AT THE UNIVERSITY OF MICHIGAN	389
a. Equipment	389
b. Results and Conclusions	390
6. SOLID-LIQUID SEPARATION TESTS DEVELOPED AT OAK RIDGE NATIONAL LABORATORY	393
(1) Vacuum Filtration	393
a. Equipment	393
b. Results and Conclusions	393
(2) Pressure Precoat Filtration	393
a. Equipment	393
b. Results and Conclusions	393
(3) Sedimentation	394
a. Equipment	394
b. Results and Conclusions	395
(4) Bench-Scale Tests	395
a. Equipment	395
b. Results	395
7. SEDIMENTATION AND FILTRATION SYSTEM WITH X-RAY PHOTOGRAPHY TECHNIQUE DEVELOPED AT WEST VIRGINIA UNIVERSITY	395
a. Principle	395
b. Equipment	395
c. Results and Conclusions	403
8. REFERENCES	403

CONTENTS OF APPENDIX

	<u>Page</u>
APPENDIX A A SUMMARY OF COAL LIQUEFACTION PROCESSES DEVELOPED IN THE U.S. by D.D. Whitehurst, T.O. Mitchell, M. Farcasiu, and J.J. Dickert, Jr.	405
1. CONOCO TWO-STAGE LIQUEFACTION (CSF) PROCESS	406
2. DOW COAL LIQUEFACTION PROCESS	407
3. EXXON DONOR SOLVENT PROCESS	407
4. H-COAL PROCESS	408
5. SRC-I PROCESS	409
6. SRC-II PROCESS	410
7. ZINC HALIDE COAL LIQUEFACTION PROCESS (CONOCO-SHELL)	410
APPENDIX B SOLID-LIQUID SEPARATION APPLIED TO COAL LIQUEFACTION PROCESSES by D.E. Briggs, and J.A. Stirling	412
1. FILTRATION	414
2. HYDROCLONES	415
3. CENTRIFUGING	416
4. DISTILLATION	417
5. CARBONIZATION (FLUID COKING)	418
6. SETTLING	419
7. WATER WASHING	420
8. ELECTROSTATIC PRECIPITATION	421
9. MAGNETIC SEPARATION	422
10. SOLVENT PRECIPITATION	422
11. SOLIDS AGGLOMERATION	423
12. FOAM FLOTATION	424
APPENDIX C SOME IMPORTANT ARTICLES RELATED TO COAL LIQUEFACTION WITH LITERATURE REVIEWS	425
1. SOLIDS SEPARATION IN THE EXXON DONOR SOLVENT PROCESS DEVELOPMENT by R.J. Fiocco	426
(1) Original Paper	426
(2) Literature Review	445

	<u>Page</u>
2. THE DOW COAL LIQUEFACTION PROCESS by N.G. Moll, and G.J. Quarderer	459
(1) Original Paper	459
(2) Literature Review	465
3. SEPARATION OF SOLIDS FROM COAL LIQUEFACTION PRODUCTS VIA COUNTERCURRENT SOLVENT DEASPHALTING by G.J. Quarderer, and N.G. Moll	467
(1) Original Paper	467
(2) Literature Review	492
4. FILTRATION IN COAL LIQUEFACTION: INFLUENCE OF FILTRATION CONDITIONS IN NON-HYDROGENATED SYSTEMS by J.W. Clarke, and T.D. Rantell	495
(1) Original Paper	495
(2) Literature Review	503
5. CLEANING OF COAL OILS BY FILTRATION by I. Romey, and R. Pass	506
(1) Original Paper	506
(2) Literature Review	510
APPENDIX D LITERATURE REVIEWS OF SOME IMPORTANT ARTICLES RELATED TO COAL LIQUEFACTION	512
1. COAL LIQUEFACTION -- GENERAL	513
(1) Coal Liquefaction at CRE by J. Gibson	513
(2) Coal Liquefaction at the Cresap, W. VA. Pilot Plant by J.A. Phinney	515
2. CHARACTERIZATION AND PROPERTIES.....	519
(1) Particle Size Analysis in the SRC Process by Coulter Counter by C.W. Curtis, A.R. Tarrer, and J.A. Guin	519
(2) Charge Characteristics of Particles in Coal Derived Liquids: Measurement and Origin by J.D. Henry, Jr., and M.T. Jacques	521
(3) Characterization by Scanning Electron Microscopy of Mineral Matter in Residues of Coal Liquefaction by S.J. Russell	523
(4) Analysis of Solvent-Refined Coal, Recycle Solvents, and Coal Liquefaction Products by J.E. Schiller	524
(5) Coal-Derived Product Effects on Viscosity by M.G. Thomas, and B. Granoff	526
3. SOLID-LIQUID SEPARATION -- GENERAL.....	529
(1) Solids-Liquid Separation in H-Coal Development by W. Karolkiewicz, and W. Volk	529