

Table of Contents

Secondary Fiber Recycling
01993 TAPPI PRESS
Atlanta, Georgia

- iii Preface
- v List of Contributors
- vii Table of Contents
- ix List of Figures and Tables

Chapter 1

Recovered Paper and the U.S. Solid Waste Dilemma I 1

by Rodney Young

- Introduction and Overview 1
- Paper Industry Response to the Solid Waste Issue 2
 - U.S. Recovered Paper Consumption 2
 - U.S. Trade in Recovered Paper 3
 - U.S. Recovered Paper Recovery 3
 - Recovered Paper Supply and Cost 3
- Bibliography 4
- Resources 4

Chapter 2

Recycled- Versus Virgin-Fiber Characteristics: A Comparison / 7

by R. L. Ellis and K. M. Ssdlachsk

- Introduction 7
- Literature Review 8
 - General Effect of Recycling 8
 - Effect of Furnish 10
 - Effect of Initial Beating of Virgin Pulp 10
 - Theory for Tensile Strength of Paper 10
 - First Assumption 11
 - Second Assumption 12
 - Theory Verification 12
- Interactions Between Fiber Properties and Process Variables 14
- Reformulation of the Page Equation 15
 - Approach 15
 - Results and Discussion 16
 - Fiber Strength 16
 - Coarseness/Perimeter 16
 - Freeness Change of Recycled Fibers 18
- Conclusions 19
- Bibliography 19
 - Literature Cited 19

Chapter 3

Print Quality of Recycled-Fiber Papers: A Review / 21

by Joseph S. Aspler

Introduction	21
Changes in Fiber Properties and Their Influence on Sheet Structure	21
Changes in Printing Properties	22
Newsprint and Mechanical Grades	22
Coated and Wood-Free Grades	23
Fines and Ink Holdout	23
Optical Properties	24
Linting and Picking	24
Water Absorbency of Recycled-Fiber Paper	25
Dimensional Stability	25
Web Breaks	25
Summary and Conclusions	26
Acknowledgements	26
Bibliography	26
Literature Cited	26

Chapter 4

The Impact of Secondary Fiber on the Paper Machine / 29

by William E. Smith and Unds Brooks Bunker

Introduction	29
Machine R unnability	29
Buildup of Suspended Solid?	29
Suspended Particulate Materials	30
Microbiological Deposits	32
Buildup of Dissolved Solid?	32
Fiber Fragments and Suspended Wood Tissue	33
Sheet Properties	34
Residual Contamination	34
Effects of Dried Fibers and Higher Fines Content	35
Bibliography	36
Resources	36

Chapter 5

Fiber Reactivity Versus Chemical Use / 37

by J. M. Gess

Introduction	37
Background	37
Discussion	38
The Handling of Noncellulosic Particulate Materials from Waste	38
Potential Problems Relating to Those Chemicals Coming with Waste Fibers	38
Carry-Over from the Preparation of Recycled Fibers	39
The Use of Strength Additives, Sizing Agents, and Retention Aids in Furnishes	39
Containing Large Amounts of Recycled Fiber	39
Conclusions	40
Bibliography	40
Literature Cited	40

Chapter 6 Characterization of Wastes and Emissions from Mills Using Recovered Fiber / 41

by **Reid Miner**, Arun Someshwar, Paul **Wiegand**,
Robert **Fisher**, Herbert **Berger**, **Dennis** Baton, and Jay **Unwin**

Introduction	41
Wastewater Characteristics	41
Wastewater Loads	41
Wastewater Treatment Technologies	47
Specific Chemical Constituents of Wastewaters	48
PCBs in Wastewaters	48
Bioassay Responses	50
Air Emissions	55
Repulping and Deinking Operations	55
Bleaching Operations	56
Manufacture of Paper and Board	56
Volatilization in the Waste Treatment System	56
Burning of Recovered-fiber Wastes and Fossil Fuels	58
Solid Wastes from Recovered-fiber Paper Mills	60
The Origin of Solid Wastes	60
Pulper	60
Contaminant Removal Prior to Deinking	60
Deinking	60
Contaminant Removal After Deinking	60
Factors That Influence Solid-waste Characteristics	60
Quantities of Solid Waste Produced	61
Sludge Dewatering	62
Physical Properties of Recovered-fiber Sludge	62
Ash Content	62
Other Physical Properties	64
Chemical Properties of Recovered-fiber Sludge	64
Constituents of Sludge Extracts	65
PCBs in Deinking Sludges	65
Sludge Disposal Alternatives	65
Current Practices	65
Research into Alternative Disposal Methods	65
Summary	65
Bibliography	67

Chapter 7 Nonpaper Uses for Recovered Paper / 69

by Thomas Frlberg

Scope and Opportunity	69
Description of Raw Materials	69
Products	70
Loose Fiber	70
Fuel	70
Insulation	70
Molded Pulp	72
Animal Bedding	72
Fillers	72
Bonded Systems (Composites)	73

Chemical Derivatives	73
Processes	73.
Collection	73
Sorting	73
Wet Processing	73
Dry Processing	73
Chemical Processing	73
Recyclability	73
Economic Considerations	74
Summary	74
Bibliography	74

Chapter 8
Sourcing and Grading of Secondary Fiber / 75

by **Daniel B. Mulligan**

Introduction	75
Considerations	75
EPA Guidelines	76
Sourcing	76
Grading	77
Bibliography	78

Chapter 9
Recovered Paper Contaminants / 79

by **Barbara M. Balos and James V. Patterson**

Introduction	79
Paper Additives Become Potential Contaminants	79
Relationships Between Products from Secondary Fiber and Their Original Paper Sources	79
Review of Major Contaminants , Resulting Problems, and Methods of Removal	81
Fillers, Clays, Titanium Dioxide, Calcium Carbonate, and Talc	81
Rosin, Alum, Natural Resins, and Wax Sizes	81
Starches and Gums	81
Dyes and Pigments	82
Inks	82
Hot-Melts , Plastic Coatings, and Asphalts	82
Loose Plastic, Styrofoam, and Treated Tapes	82
Heavy Materials	82
Conclusion	82
Bibliography	82

Chapter 10
Introduction to Secondary-Fiber Processing / 85

by **Richard J. Spangenberg**

Chapter 11 Receiving, Inspection, and Storage of Secondary Fiber / 87

by Bob Miller

Receiving	87
Transportation	87
Unloading and Handling Equipment	88
Inspection	88
Sorting	88
Material Specifications	88
Storage	88
Bibliography	89

Chapter 12 Pulping of Secondary Fiber / 91

by F. Clint Cleveland

Introduction	91
Pulping of Secondary Fiber	91
Pulper Feed Conveyor	91
Pulper Feeding Control	93
Pulping Variables	94
Chemicals	95
Causlic (Sodium Hydroxide)	95
Hydrogen Peroxide	95
Hydrosulfite/Formamidine Sulfonic Acid (FAS)	95
Sodium Silicate	95
Chelant	95
Collector	95
Anionic	95
Cationic	95
Ampholitic	95
Nonionic	95
Dispersant	95
Displectors	96
Equipment Operation	96
Process Consideration/Design Points	96
Pulper Types	97
Pulping Innovations	99
Conclusion	100
Bibliography	100

Chapter 13

Cleaning for Contaminant Removal in Recycled-Fiber Systems 1 101

by **Kevin Merriman**

Introduction	101
Forward Cleaners	103
Theory	103
Forward Cleaner Design	105
Chamber Diameter	105
Chamber Length	106
Cone Angle	106
Vortex Finder Length	106
Feed Orifice Diameter	106
Accepts Orifice Diameter	106
Rejects Orifice Diameter	106
Controlled Turbulence	106
Construction Materials	106
Canister Configurations	108
Forward Cleaner Operating Parameters	108
Feed Consistency	108
Operating Pressures	109
System Temperature	109
Stock Freeness	109
Reject Rate	110
Control of Operating Parameters	111
System Design and Cleaner Selection	111
Elutriation and Fiber Recovery	113
Coarse Cleaning	115
Lightweight Cleaners	116
Reverse Cleaners	117
Through-Flow Cleaners	118
Design and Operating Considerations for Hydrocyclone-Type Lightweight Cleaners	119
The Gyroclean	119
Comparison of Lightweight Cleaners	122
Core-Bleed Cleaners	122
Bibliography	122

Chapter 14

Screening / 125

by **Terry Blinn**

Introduction	125
Debris in Secondary Fiber	125
Debris Size, Shape, and Orientation	125
Pressure Screen Principles	126
Mechanism of Debris Removal in Pressure Screens	128
Positive Size Separation	128
Debris Orientation	128
Other Debris Removal Mechanisms	129
Pressure-Screen Cylinders	129
Holes	129
Slots	129
Turbulence-Generating Screen Cylinder Designs	130

Measuring Screen Performance	131
Debris Rejection	131
Rejection of Long Fibers	132
Determining Debris Content	132
Pressure Screen Applications in Secondary-Fiber Systems	133
Controlling Pressure Screens	133
Secondary Pulpers	134
Rejects Screens	134
Vibrating Screens	134
Batch Reject Screens	135
Modern Continuous Reject Screens	136
Screening-System Design Considerations	136
Avoid the Disintegration of Debris	138
Series Screening	138
Match Tailing Efficiency to the Efficiency of the Main Stream	138
Practice Good Housekeeping and Maintenance	138
Strive for Stable Operation	138
Summary	138
Bibliography	139
Literature Cited	139

Chapter 15 Flotation Deinking / 141

by **Michael A. McCool**

Introduction	141
Flotation Deinking Market	141
Flotation Theory	141
Flotation Chemistry	142
Deinking Chemicals	143
Soaps	143
Synthetic Collectors	144
Flotation Cells	144
History of Flotation Deinking Cells	144
Modern Flotation Deinking Cells	145
Beloit PDM Flotation Cell	147
Bird-Escher Wyss CF/CFS/CFC Cells	147
Black Clawson IHI/BC Flotation Cell	150
Lamort DA Verticel	151
Kamyr GSC Flotation Device	152
Voith Multi-Injector Elliptical Cells	152
Other Flotation Cells	153
Flotation Deinking Systems	153
Flotation Only Systems	153
Combination Systems	154
Single-Loop Combination Systems	154
Two-Loop Combination System	154
Acid Loop Systems	154
Post Flotation Loop	155
Washing Loop	156
Soaking Stage	156
Three-Loop Combination System	157
Measurement of Flotation Efficiency	157

Brightness	157
Ink Removal	159
Stickies Removal	159
Rejects Rate	159
Deinking Efficiencies	159
Quality of Deinked Pulp	160
Conclusions	160
Bibliography	161
Literature Cited	161

Chapter 16 Washing / 163

by **R.G. Horacek** updated by **William Forester**

Introduction	163
Washing	163
Froth Flotation	163
Other Mechanical Devices	163
Thickening vs. Dilution Washing	163
Theory of Countercurrent Dilution Washing	163
Hot-Loop System Design	165
Effect of Particle Size and Ink Dispersion	166
Operating Characteristics of Washers	169
Low-Consistency Washers	169
Sidehill Screens	169
Gravity Deckers	170
DSM Screens	172
Hydrasieves	173
Intermediate-Consistency Washers	173
Inclined Screw Extractor	173
Vacuum Filter	176
Vario Split	176
Double-Nip Thickener	176
High-Consistency Thickeners	177
Screw Press	177
Economic Comparison of Washing Devices	178
Comparison of Washing and Froth Flotation	179
Bibliography	183
Literature Cited	183

Chapter 17 Conditioning of Secondary Fibers / 185

by **Bill Carty**

Introduction	185
Differences Between Secondary and Virgin Fibers	185
General Aspects of Refining	185
Purpose of Refining	185
Refining Mills	185
Wood Fiber Structure	186
The Refining Process	186
Refining Action	186
Refining Intensity and Refining Power	187

Refining Consistency	188
Other Considerations	188
Double-Disk Refiner	188
Stock Flow	189
Refiner Plates	189
Secondary-Fiber Refining	190
OCC for Board Grades	190
Other Considerations for OCC	191
Fractionation and Refining	191
High-Consistency Refining	191
Deinked Ledger Grades for White Paper	192
Deinked Newsprint for Newsprint	193
Refiner Piping Arrangement	193
Typical Refiner Installation	194
Series Arrangement	194
Parallel Arrangement	194
Deflaking	194
Conclusion	195
Bibliography	195

Chapter 18

Dispersion of Contaminants in Recovered Paper Stock / 197

by A. C. Alexander, Roll Kurtz, and Donald H. McBride

Introduction	197
The Process of Dispersion	197
Development of Dispersion Systems	197
Dispersing Factors	198
Heat-Softening of Contaminants	198
Contaminant Size Reduction and Mixing	198
The Blow Valve	198
Disk Refiner	198
Kneading Machines	198
The Dispersion System	199
Thickening Stage	200
Heating Zone	202
Dispersion	202
Kneading-Type Dispersers	202
The Future of Dispersion Systems	202
Case Studies	204
The Effects of Dispersion on Flotation for Ledger Furnishes	204
Cold Dispersion Increases Deinking Efficiency at Japanese Tissue Mills	204
Further Japanese Mill Experience	205
Deinking of ONP for Newsprint Production	206
Placement of Kneading Equipment	206
Bibliography	206

Chapter 19

Fractionation of Fibrous Stocks:

Fundamentals. Process Development. Practical Application / 207

by **W. Musselmann**

Introduction	207
Fractionation—An Effective Approach Toward Limiting the Variant Physical Properties of Raw Materials and Controlling Their Quality	207
Theoretical Considerations of Fractionation Technology	207
Example 1—Fractionation and Joint Processing	209
Example 2—Fractionation and Separate Processing	210
Theoretical Considerations and Laboratory Tests for Limiting Recovered Paper Physical Properties	211
Demands on a Fractionation System	212
Variables Influencing the Fractionation Effect	212
Terminology	212
Machine Parameters	212
Process Variables	214
Example 1—Fractionation of Department Store Waste	214
Example 2—Fractionation of Sorted Mixed Recovered Paper	214
Preparation of Fractions	216
LF and SF Characteristics	216
LF Fraction Preparation	216
LF Strength Development and Energy Consumption	216
SF Fraction Preparation	217
Energy Use of Separate Refining Compared with Full-Stream Refining	217
Range of LF and SF Fraction Applications	218
Practical Examples	218
Possible Configurations	219
Slushing—Screening—Fractionation—Separate Refining and Dispersion—Separate Processing	219
Slushing—Prescreening—Fractionation—Separate Refining—Joint Processing	225
Slushing—Prescreening—Separate Refining and Dispersion—Joint Processing	225
Control and Regulation	225
Outlook	226
Conclusion	226
Bibliography	227

Chapter 20

Bleaching of Secondary Fiber / 229

by **Jeffrey E. Angulo**

Introduction	229
Bleaching Deinked Newsprint	229
Avoid Alkali Darkening	230
Two-Stage Bleaching	231
Bleaching of Chemical Pulps	232
Tissue/Towel, Printing and Writing, and Market Pulps	232
Low Chlorine/Hypochlorite Bleaching	232
Nonchlorine Bleaching	236
Bleaching of Postconsumer Office Wastes	237
Bibliography	237

Chapter 21

Process Water Clarification / 239

by **Lewis H. Mahony**

Introduction	239
Water Recovery for Recycling	239
Heat Conservation	240
Fiber and Ash Recovery	241
Chemical Recovery	241
Paper-Machine White Water Clarification	242
Effluent Treatment	242
Primary Effluent Clarification	242
Secondary Effluent Clarification	242
Tertiary Effluent Treatment	242
Equipment	242
Chemical Requirements	243
Process Reviews	243
Economic Return from Recycling Water in a Board Mill	243
Zero-Effluent Water System at a Mill Producing Linerboard and Corrugating Medium	244
Washing Loop in a Tissue Mill Using Deinked Fiber	246
Secondary Effluent Clarification	246
Conclusion	247
Bibliography	247

Chapter 22

Rejects Handling and Sludge Pressing in Recycling and Deinking Systems / 249

by **Don McBride**

Introduction	249
Rejects Handling	249
Contaminants vs. Rejects	249
Types of Contaminants	249
Sources of Rejects	250
Rejects Conveying	250
Wires	250
Rejects Dewatering	251
Inclined Screw Thickeners	251
Reciprocating Piston Presses	251
Dewatering Gritty Rejects	252
Sediment Separators	252
Configuration of Rejects-Handling Equipment in a Deinking Facility	252
Sludge Pressing	252
Dewatering Parameters	253
Sludge Composition	254
Equipment Review	254
Plate and Frame Press	254
Centrifuge	255
Vacuum Filter	256
V-Belt Press	256
Belt Filter Press	256
Screw Press	257
Sludge-Thickening Process Flow	258
What Lies in the Future for Sludge Dewatering?	258

Disposal Alternatives and Equipment Selection	258
Conclusion	259.
Bibliography	259.

Chapter 23
Flowsheet Considerations / 261

by **Timothy K. Eatee** and **Richard J. Spangenberg**

Introduction	261
Process Parameters that Influence the Design of Flowsheets	261
Examples of Flowsheets	262
Very Simple System	262
Crude Cleaning	262
OCC System	264
Systems for Deinking Newsprint and Magazine Papers	264
Deinking of Printing and Writing Grades	266
Conclusion	268