

Papermaking Science and Technology

a series of 19 books

covering the latest

technology and

future trends

Book 17

Pulp and Paper Testing

Series editors

Johan Gullichsen, Helsinki University of Technology

Hannu Paulapuro, Helsinki University of Technology

Book editors

Jan-Erik Levlin

Liva Söderhjelm



Series reviewer

Brian Attwood, St. Anne's Paper and Paperboard Developments, Ltd.

Book reviewer

James C. Abbott



Published in cooperation with the Finnish Paper Engineers' Association and
TAPPI

Table of Contents

1.	Aim of pulp and paper testing	12
2.	Single fiber properties	19
3.	Papermaking properties of pulp	39
4.	Properties of recycled pulps.....	65
5.	Fluff pulps	95
6.	Chemical analysis of pulps	111
7.	General physical properties of paper and board	137
8.	Optical properties of paper	163
9.	End-use properties of printing papers	183
10.	End-use properties of packaging papers and boards	217
11.	Hygiene papers	233
12.	Permanent papers	249
13.	Reliability of results in physical testing of pulp and paper.....	257
14.	Standardization in pulp and paper testing	269
	APPENDIX	276
	Conversion factors	281
	Index	284

CHAPTER 1

Aim of pulp and paper testing

1	Why test pulp and paper products?	12
2	Selecting proper tests and analyses	13
2.1	Process analysis	13
2.2	Product analysis	14
2.3	Examples of selecting tests	14
2.3.1	Defining tests for use in a process control system	14
2.3.2	Defining tests for use in process and equipment development.....	15
2.3.3	Defining tests to be used for describing paper products	16
3	Testing vs. characterization	16
	References	17

CHAPTER 2

Single fiber properties

1	Introduction	19
2	Identification of pulp fibers	19
2.1	Identification of wood species	19
2.2	Identification of different types of pulp	19
3	Fiber dimensions and their variations	20
3.1	Variations in wood fiber dimensions	20
3.2	Variations in pulp fiber dimensions	21
4	Measurement of fiber dimensions	22
4.1	Fiber length	22
4.2	Fiber width and fiber wall thickness	23
5	Fiber properties	25
5.1	Stiffness	25
5.2	Fiber surface fibrillation	26
5.3	Fiber wall porosity	27
5.4	Single fiber strength	28
5.5	Evaluation of single fiber strength from zero-span tensile strength measurement	30
5.6	Quantification of fiber deformations	30
6	Reasons for single fiber measurements	34
	References	35

CHAPTER 3

Papermaking properties of pulp

1	Traditional laboratory testing procedure	39
1.1	Handling pulp before the experiments	40
1.2	Dry matter content of pulp	40
1.3	Stock consistency	40
1.4	Disintegration of pulp	41
1.5	Laboratory beating of chemical pulp	41
1.6	Classical laboratory beaters	42
1.7	Laboratory refiners	44
1.8	Dewatering properties of pulps	44
1.9	Analysis of fiber length, coarseness, and strength	47
1.10	Preparation of laboratory sheets	48
1.11	Laboratory wet pressing	49
1.12	Drying of laboratory sheets	49
1.13	Calendering of laboratory sheets	50
1.14	Conditioning and testing of laboratory sheets	50
2	Evaluating the papermaking potential of pulps	50
2.1	Traditional pulp evaluation	50
2.2	Problems of the traditional pulp evaluation method	51
2.3	Use of property pairs for pulp comparison	51
2.4	Quality potential of chemical pulps	52
2.5	Mechanical pulps	54
3	Furnish optimization	54
3.1	Optimization problems using single pulp testing	55
3.2	Testing strategy for ranking pulps	55
3.3	Product analysis	55
3.4	Process analysis	56
3.5	Furnish optimization procedure	57
3.6	Evaluation of furnish optimization method	60
	References	61

CHAPTER 4

Properties of recycled pulps

1	Introduction	65
2	Quality aspects of recovered paper	65
3	Sample preparation and testing of recovered paper	66
3.1	Stock characteristics	69
3.1.1	Ash	70
3.1.2	Stickies	71
3.1.3	Beating behavior	79
3.2	Strength properties	79
3.3	Optical properties	81
3.4	Cleanliness of pulp and filtrates	83
3.4.1	Dirt specks and residual ink	83
3.4.2	Filtrate properties	84
4	Testing of paper products	85
4.1	Ink detachment	85
4.2	Deinking	87
4.2.1	Flotation	88
4.2.2	Washing	90
	References	92

CHAPTER 5

Fluff pulps

1	Introduction	95
2	Testing of basic pulp properties	96
2.1	Pulp properties measured from the original pulp sheet in the dry state	97
2.1.1	Brightness	97
2.1.2	Moisture content	97
2.1.3	Basis weight, thickness, and sheet density	97
2.1.4	Bursting strength.....	97
2.1.5	Extractives	97
2.2	Pulp properties measured in wet state	98
2.2.1	Freeness and pH.....	98
2.2.2	Fiber morphology (Fiber length, amount of fines, coarseness, and fiber curl).....	98
3	Testing of fluff properties	98
3.1	Specific shredding energy	99
3.2	Dry and wet network strength	100
3.3	Knot content	100
3.4	Absorption tests developed by SCAN-test: absorption capacity, absorption time, and specific volume 101	
3.5	Other test methods	102
3.5.1	Demand wettability	102
3.5.2	Absorption and retention	103
3.5.3	Vertical wicking	103
3.5.4	Rewetting tests.....	103
3.6	Liquid acquisition	103
3.6.1	MTS acquisition test.....	104
3.6.2	Testing of acquisition and rewetting by Kanga testing apparatus	105
3.7	Consumer tests compared with laboratory tests	106
	References	107

CHAPTER 6

Chemical analysis of pulps

1	Introduction	111
2	Dry matter content	111
3	Carbohydrates	112
3.1	Carbohydrate composition	112
3.2	Pentosans	113
3.3	Division of carbohydrates according to alkali solubility	113
3.4	Determination of carbohydrate molecular mass and degree of polymerization	114
3.4.1	Different molecular masses, polydispersity	114
3.4.2	Viscosity measurements.....	115
3.4.3	Gel permeation chromatography	116
3.5	Functional groups present in carbohydrates	118
3.5.1	Carbonyl groups	118
3.5.2	Carboxyl groups	119
3.5.3	Uronic acids	119
3.6	Carbohydrate studies using FTIR spectroscopy	120
4	Lignin	120
4.1	Quantitative determination of lignin	120
4.2	Degree of delignification	121
4.3	Characterization of lignin	122
4.3.1	Methoxyl groups.....	122
4.3.2	Sulfonic acid groups.....	123
4.3.3	Phenolic hydroxyl groups.....	123
4.3.4	Molecular mass distribution	123
4.3.5	Spectroscopic methods.....	123
4.3.6	Pyrolysis.....	125
5	Organic extractives	126
5.1	Total extractives	126
5.2	Analysis of extractives	127
6	Fiber surface composition	127
7	Dirt and shives in pulp	128
8	Color reversion	128
9	Inorganic matter	129
9.1	Ash and its components	129
9.2	Chlorine compounds	130
9.3	Other elements	131

CHAPTER 6

9.4	Properties and components of water extracts	131
9.4.1	pH and conductivity of water extracts of pulp.....	131
9.4.2	Water soluble sulfates and chlorides	131
9.4.3	Estimation of washing efficiency	131
10	Analysis of dissolving pulps	132
11	Future of chemical analyses	132
	References	133

CHAPTER 7

General physical properties of paper and board

1	Preparations for testing	138
1.1	Sampling	138
1.2	Conditioning	138
2	Basic properties	140
3	Strength properties	141
3.1	Tensile strength	142
3.2	Bursting strength	144
3.3	Internal tearing resistance, tearing strength	145
3.4	Folding endurance	147
3.5	Zero-span tensile strength	148
3.6	Surface strength	148
3.7	Z-directional strength of paper	150
4	Stiffness properties	151
4.1	Tensile stiffness	151
4.2	Bending stiffness	152
4.3	Stiffness by the resonance method	154
4.4	Determination of stiffness properties by sonic testing	155
5	Structural properties	155
6	Surface properties	156
7	Absorption properties	158
	References	160

CHAPTER 8

Optical properties of paper

1	Interactions of light and paper	163
2	Gloss	164
3	Reflectance measurements	165
3.1	Basic concepts	165
3.2	Numerical description of lightness and color	168
3.3	ISO brightness, R457	173
3.4	Y value	174
3.5	Whiteness	174
3.6	Opacity	175
3.7	Light scattering and light absorption coefficient	176
4	Measuring the reflectance of fluorescent materials	177
5	Equipment	178
5.1	Methods of measurement	178
5.2	Instrumental factors influencing test results	178
	References	181

CHAPTER 9

End-use properties of printing papers

1	Runnability	184
1.1	Runnability in web printing	184
1.1.1	Paper strength and strain profiles.....	184
1.1.2	Cracking	186
1.1.3	Blistering	187
1.2	Runnability in sheet fed printing	187
1.2.1	Curl.....	188
1.2.2	Static electricity	190
1.2.3	Bending stiffness.....	191
1.2.4	Dimensional stability	193
1.2.5	Heat induced curl.....	193
1.2.6	Drying of paper.....	194
1.2.7	Cockling.....	195
1.3	Testing of time dependent runnability problems	197
1.3.1	Linting (or dusting) and picking	198
1.3.2	Piling (carry-over piling).....	199
2	Printability and print quality	199
2.1	General paper quality	200
2.1.1	Roughness	200
2.1.2	Gloss variation.....	201
2.1.3	Absorption properties.....	202
2.1.4	Surface chemistry of paper.....	203
2.2	Testing of printability and print quality on a laboratory scale	204
2.2.1	Some examples of laboratory scale printability and print quality tests	206
2.3	Full-scale printing trials	211
	References	212

CHAPTER 10

End-use properties of packaging papers and boards

1	Introduction	217
2	Strength and stiffness properties	218
2.1	Strength properties	218
2.2	Bending stiffness	218
2.3	Compression resistance tests	219
2.4	Creasability	222
3	Tests for corrugated fiberboard	222
4	Effect of humidity and viscoelastic behavior of paper and board	224
5	Protection and barrier properties	224
6	Paper and board as food packaging materials	226
6.1	Sensory analysis	226
6.2	Migration tests	227
6.3	Analyses of extracts	227
6.4	Microbiological properties	228
6.5	Future demands	228
	References	229

CHAPTER 11

Hygiene papers

1	Sampling and conditioning	234
2	Curing	235
3	Grammage (Basis weight)	236
4	Thickness	236
5	Absorbency properties	238
6	Tensile strength and stretch	241
7	Wet tensile strength	242
8	Softness	244
9	Other properties of tissue	245
	References	246

CHAPTER 12

Permanent papers

1	Historical aspects	249
2	Requirements and tests for permanence	251
2.1	Composition and properties	251
2.2	Accelerated aging	252
3	Categories of permanent papers	253
	References	254

CHAPTER 13

Reliability of results in physical testing of pulp and paper

1	Introduction	257
2	Importance of knowing the uncertainty of measurement	257
3	Uncertainty, repeatability, and reproducibility	258
4	Procedure for evaluating and expressing the uncertainty of measurement	259
4.1	Basic procedure	259
4.2	Practical application for pulp and paper testing	260
5	Main components of uncertainty in pulp and paper testing	262
5.1	Material and sampling	262
5.2	Test method used	263
5.3	Equipment	263
5.4	Test environment	264
5.5	Personnel	264
6	Size of the uncertainty, repeatability, and reproducibility in different measurements	264
7	Summary	265
	References	266

CHAPTER 14

Standardization in pulp and paper testing

1	Introduction	269
2	Standardization bodies	270
3	ISO	270
3.1	General aspects	270
3.2	Development of a standard	271
3.3	ISO work related to pulp, paper, and board	271
4	CEN	273
4.1	General aspects	273
4.2	Development of standards	273
4.3	CEN work related to pulp, paper, and board	273
5	Industrial branch standards	274
5.1	SCAN-test	274
5.2	TAPPI	274
6	Benefit of standards	274
	References	275