

"Paper Machine Design and Operation--Descriptions and Explanations" **By Gunnar Gavelin**

1998., 222 pp., Published by Angus Wilde
Item Number: 08AWPMD
ISBN: 0-9694628-2-4

This new book offers an update on current paper machine developments and operating practices and compares design approaches by major paper equipment manufacturers. Seven chapters cover the following topics: Approach Flow, Headboxes, Fourdrinier Wet End, Twin Wire Formers, Press Section, Drying of Paper, Surface Treatment of Paper.

TABLE OF CONTENTS

PREFACE	vii
ACKNOWLEDGEMENTS	viii
CHAPTER 1 -- APPROACH FLOW	
1.1 Introduction – Basics of Papermaking	1
1.2 Definitions and Nomenclature	2
1.3 White Water System	3
Short Circulation	3
Long Circulation	5
1.4 Machine Refiners	5
1.5 Stuff Box	5
1.6 Basis Weight Valve	6
1.7 Basis Weight Variations	6
1.8 Fan Pump	7
1.9 Headbox Feed Pump	8
1.10 Centricleaners	8
1.11 Deaeration	8
1.12 Screens	10
References	12
CHAPTER 2 – HEADBOXES	
2.1 Headbox With Air Cushion	13
Flow Spreader	14
Flow Distributor	14
Headbox Proper	15
Perforated Rolls	15
Air Cushion	17
2.2 Hydraulic Headbox	18
2.3 Slice	19

"Paper Machine Design and Operation--Descriptions and Explanations"

By Gunnar Gavelin

2.4	Acceleration of Flow in the Headbox	20
2.5	Fiber Angle	21
2.6	Dilution Control	22
	Voith Module Jet	23
	Beloit System	25
	Valmet system	26
2.7	Precision Demands on Headbox Surfaces	28
2.8	Hydraulic Headbox Developments	28
	Beloit converflo	30
2.9	Multichannel Headbox	32
	Why Multichannel Headboxes?	34
2.10	Headbox Effects on formation and MD/CD Ratio	35
2.11	Length of the Free Jet	35
2.12	Efflux Ratio	35
2.13	Automation of Headbox Operation	37
	References	38

CHAPTER 3 – FOURDRINIER WET END

3.1	Fourdrinier Components	40
	Breast Roll	41
	Deckle Rulers	41
	Forming Board	41
	Table Rolls	42
	Foils (Foil blades)	42
	Wet Suction Boxes	44
	Dry Suction Boxes	44
	Dandy Roll	45
	Couch Roll	47
	Couch Press	48
	Wire Turning Roll	49
3.2	Closed Transfer	49
3.3	Forming Fabric	50
	Fabric Designs	50
	Seaming	51
	Fabric Quality	52
3.4	Auxiliary Rolls	54
	Guide and Stretch Rolls	54
	Bowed Roll	56
3.5	Fabric Cleaning	58
	High Pressure Showers	58
	Voith Jetcleaner	60
3.6	Drainage Along the Wire Table	61
3.7	Elements of the White Water System	62
	Dry Suction Box Seal Pit	62
	Wire Pit	63
	White Water Tanks	63

"Paper Machine Design and Operation--Descriptions and Explanations"

By Gunnar Gavelin

	White Water Cleaning	64
3.8	Broke System	66
	Couch Pit	66
	Dry Broke	67
3.9	Wire Retention	68
3.10	White Water system Closure-	
	Reducing Fresh Water Usage	69
3.11	Cleaning of Paper Mill Effluent	70
	References	71

CHAPTER 4 – TWIN-WIRE FORMERS

4.1	Blade Former	73
	Drainage Process on a Blade Former	74
4.2	Roll Former	75
	Drainage Process on a Roll Former	75
4.3	Hybrid Former	77
	Valmet Sym-Former	77
	Beloit Bel Bond	79
	Voith DuoFormer D	80
4.4	Roll-blade Former	81
4.5	New Blade Forming Technology	82
4.6	Geometry of the Entering Nip	82
	Problems of Two-Sidedness	84
4.7	Description of Specific Formers	84
	Valmet Speed Former	85
	Valmet Speed Former MB	86
4.8	Speed Former and Paper Quality	87
4.9	Blade-Roll Former	88
4.10	Description of Specific Formers	88
	Bel Baie III	88
	Bel Baie IV	90
	Voith DuoFormer CFD	91
4.11	Horizontal Gap Former	94
4.12	Forming Fabrics	95
4.13	Theory of Two-Sided Drainage	95
4.14	Forming Unit Alternatives	96
	Membranes in the Slice Area	96
	Optimization of Roll Drainage	97
	Blade Section Drainage	97
4.15	Paper Quality Considerations	98
4.16	High-Consistency Forming	99
4.17	Paperboard Machine Formers	101
4.18	Tissue Machine Formers	103
	Valmet "C-Wrap"	103

"Paper Machine Design and Operation--Descriptions and Explanations"

By Gunnar Gavelin

Valmet Crescent Former	104
Valmet Performer Nouveau	104
References	105

CHAPTER 5 – PRESS SECTION

5.1	The Process of Pressing	106
	Rewetting Problem	107
5.2	Plain Press	107
5.3	Suction Press	108
	Other Suction Roll Applications	109
	Suction Roll Shells	109
	Roll Shell Covers	110
5.4	Grooved Press	112
	Grooved Steel Roll	112
	Grooved Press Geometry	113
5.5	Blind-Drilled Press	114
5.6	Fabric Press	114
5.7	Long-Nip Press	115
5.8	Large-Roll Press	116
5.9	Shoe Press	116
	Design Principle	116
	Effect of Shoe Pressing on Paper Quality	118
	Press Sections With Shoe Presses	119
5.10	Double-Felted Press	122
5.11	Types of Rolls	123
	Antideflexion (Controlled Crown) Rolls	123
	Granite Rolls	125
	Composite-Covered Rolls	126
	Peeler Rolls	126
5.12	Examples of Press Sections	127
	Two-Nip Press Sections	127
	Three-Nip Press Sections	127
	Fourth Nip	129
5.13	Pressing at High Temperature	130
	Steam Boxes	130
	Hot Presses	131
5.14	Open-Draw Presses	134
	Theory and Practice of Open Draws	135
5.15	Closed Transfer – Press Section to Dryers	137
5.16	Economics of Pressing	137
5.17	Press Felts	138
	Felt Construction	138
	Performance Requirements	139

"Paper Machine Design and Operation--Descriptions and Explanations"

By Gunnar Gavelin

	Seamed Press Felts	139
	Felt Suction Boxes	140
	High-Pressure Showering	140
	Cost of Paper Machine Clothing	140
5.18	Vacuum Pumps	140
	Water-Ring Vacuum Pump	140
	Water-Ring Pump Heat Recovery	141
	Turbo Compressor	142
5.19	Pressing and Paper Quality	143
	Shadow Marking	143
5.20	Future Development of Pressing	143
	References	147

CHAPTER 6 – DRYING OF PAPER

6.1	Cylinder Drying	149
	Heat Transfer Considerations	149
	Process Considerations	150
6.2	Yankee Cylinder and MG Cylinder Drying	151
	Yankee and MG Hoods	152
6.3	Multicylinder Drying	153
6.4	Steam and Condensate Systems	155
	Condensate Behavior	156
	Turbulence Generators	159
	Condensate Dams	160
	Condensate Removal	160
	Blow-Through Steam	160
	Control of Steam and Condensate Flows	162
6.5	Syphon Designs	166
	Rotating Syphons	166
	Stationary Syphons	167
	Syphon for Yankee Dryer	168
	Syphon Dimensions	169
6.6	Dryer Fabrics	170
	Air Permeability	170
	Cleaning	171
6.7	Multicylinder Drying – Ventilation	172
6.8	Sheet Flutter and Closed Sheet Transfer	174
6.9	New Multicylinder Dryer Designs	176
	Beloit	178
	Valmet	178
	Voith	180
6.10	Effect of Closed Transfer on Sheet Shrinkage	181
6.11	Steam Consumption	182

"Paper Machine Design and Operation--Descriptions and Explanations"

By Gunnar Gavelin

6.12	Hood Ventilation	183
	Heat Recovery	183
	Hood Air Humidity Control	184
	Hood Air Humidity Control	185
	The Dew Point	186
	Variable Speed Fans	187
	Scrubber for Exhaust Air	188
6.13	Other Types of Paper Drying Systems	188
	Air Impingement Drying	188
	Drying with Hot Air	190
	Through Drying	191
	Infrared Drying	192
	Impulse Drying	192
	Condebelt Process	194
6.14	Drying and Paper Quality	195
6.15	Control of MD and CD Moisture Profiles	197
	References	197

CHAPTER 7 – SURFACE TREATMENT OF PAPER

7.1	Smoothing Press	199
7.2	Breaker Stack	199
	Pre-Calendar	200
7.3	Size Press	200
	Traditional Size Press	200
	Film Size Press	202
7.4	Conventional Hard-Nip Calender	206
	Cooling and Control	208
7.5	Soft Calender	209
	Soft Calendering Process	210
	Soft Calendering or Supercalendering?	212
7.6	Reel	213
7.7	Paper Machine Drives	214
	References	215

CREDITS	216
----------------	-----

INDEX	218
--------------	-----

"Paper Machine Design and Operation--Descriptions and Explanations" By Gunnar Gavelin

INDEX

A

acceleration of headbox flow 20-21
 air cushion headboxes13, 17
 air drying190-191
 air impingement drying188-190
 antideflexion roll123-124
 approach flow 4
 ash content, control of 6
 auxiliary rolls 54

B

basis weight..... 2, 6
 profile control 19
 basis weight valve6, 22-26
 basis weight variations..... 6-7
 Beloit,
 Bel Baie III former 88-90
 Bel Baie IV former..... 90-91
 Bel Bond former 79-80
 Converflo headbox..... 30-32
 dryer section178
 Extended Nip Press.....116-117
 TNT Reel212
 Ultra Rock press roll.....126
 blade former 73
 blade former drainage..... 74-75
 blade forming technology..... 82
 blade section drainage..... 93
 bowed rolls 56-57
 breaker stack.....199-200
 breast roll 41
 broke system 66-67

C

calender
 hard-nip.....205-206
 soft.....208-211
 calendering.....205-212
 calender rolls,
 cooling and control of.....207-208
 centricleaners 8
 ceramic press rolls.....126
 closed transfer
 press to dryers137
 within dryers.....174-181
 effect on shrinkage.....181-182
 wire to press..... 49
 closing up the paper machine 69
 composite-covered press rolls126
 condensate

behavior 156-159
 dams 160
 removal 160
 systems 160-166
 controlled crown roll 123-124
 cost of papermachine clothing..... 140
 couch pit 66-67
 couch press..... 48
 couch roll 47-48
 cylinder drying..... 149-151

D

dandy roll 45-46
 deaeration 8-10
 deckle ruler 41
 dew point in the hood 186-187
 dilution of stock before headbox.....3-5
 dilution control headboxes.....22-27
 Beloit system25-26
 Valmet system.....26
 Voith Module Jet.....23-25
 disc filter 64-65
 doctor 111
 dominating fiber angle..... 21-22
 drainage
 blade section 74-75, 97-98
 on fourdrinier 61-62
 on roll formers 76-77, 97
 draws 135-136
 drives, paper machines 213-214
 dry broke handling..... 67
 dryer designs, new 176-181
 dryer fabric..... 170-172
 air permeability 170-171
 cleaning 171-172
 dryer hood
 dew point control 185-187
 heat recovery..... 183-184
 humidity control 185-187
 pressure control..... 184-185
 ventilation 183-187
 yankee..... 152
 dryer section
 cascade 160-163
 thermoccompressor..... 163-166
 drying
 air impingement..... 188-190
 Condebelt..... 194-195
 cylinder..... 149-151
 hot air 190-191
 impulse..... 192-194
 infrared 192
 multicylinder 153-155

"Paper Machine Design and Operation--Descriptions and Explanations"

By Gunnar Gavelin

temperature profile	155
through.....	191
yankee cylinder	151-152
drying and paper quality.....	195-197
drying process	150-151
ventilation	172-174
dry line	44-45
dry suction boxes.....	44-45

E

economics of pressing	137-138
effluent from paper mills	70
efflux ratio	35-37

F

fan pump	7-8
felts (see press felts)	
fiber angle	21-22, 35
flat boxes.....	44-45
flotation clarification.....	65-66
foils	

formers

Beloit Bel Baie III	74, 88-90
Beloit Bel Baie IV	90-91
Beloit Bel Bond	79-80
for paperboard machines.....	101-103
for tissue machines	103-104
gap.....	72-77, 81-82
twin-wire.....	72-94
Valmet Crescent Former	104
Valmet C-Wrap	103
Valmet Periformer Nouveau.....	104
Valmet Speed Former	85-86
Valmet Speed Former MB.....	86-87
Valmet Sym-Former.....	77-79
Voith Duoformer CFD.....	91-94
Voith Duoformer CV	88
Voith Duoformer D	80-81
formers and paper quality	87-88

forming

gap	
blade.....	73-75
blade-roll	88
horizontal	94
roll.....	75-77
roll-blade	81-82
high-consistency	99-100
forming board	41-42
forming fabric	50-54, 58-61, 95
cleaning	58-59
Voith jet cleaner	60-61
design	50-51
drainage capacity	53
effect on paper quality.....	54
fiber penetration	53

quality.....	52-54
seaming.....	51
speed	54
stability	53
wear	52
forming roll.....	76-77
forming shoe	78-79
fourdrinier forming section.....	41-46
drainage profile.....	61-62
fresh water consumption	69

G

granite roll.....	125-126
guide roll	54-55

H

headbox

air cushioned	13, 17
automation of operation	37-38
effects on formation.....	35
42-43 effects on MD/CD ration	35
feed pump	7-8
flow dilution for	
basis weight control	22-27
flow distributor	14
flowspreader	14
free jet length	35
hydraulic.....	18-31
membranes in slice.....	30, 96
multichannel	32-35
perforated rolls	15-16
slice.....	19-20
surfaces demands	28
surge tank.....	17
headbox proper	15
heat recovery	
in drying.....	183-184
vacuum pump.....	141-142
heat transfer equation	149
high-pressure showers.....	58-59, 140, 171-172
horizontal gap formers	94
hot pressing	130-133
hybrid former.....	77-79
hydrogen bonding.....	1

I

impulse drying.....	192-194
Isotuner (for fiber angle testing).....	21

L

long circulation	5
lumpbreaker roll	47

M

machine chest.....	3-4
--------------------	-----

"Paper Machine Design and Operation--Descriptions and Explanations"

By Gunnar Gavelin

machine screens.....	10-11
MD/CD ratio.....	21-22, 35
membranes in the slice area.....	30, 96
MG cylinder	151-152
moisture ratio.....	2
moisture profile control	195
multichannel headboxes	32-35
multiply paperboard formers	101-103

O

open draws	134-136
------------------	---------

P

paperboard machines	101-103
paper quality considerations	
drying.....	195-197
forming process	54
pressing	118-119, 143
peeler rolls.....	126
perforated rolls in headboxes.....	15-16
pre-calender	200
presses	
blind-drilled	114
double-felted	122-123
fabric.....	114-115
grooved.....	112-113
hot	131-133
large roll.....	116
long nip	115
open-draw	134
plain	107
shoe	116-122
smoothing	199
suction	108-109
press felt	
construction.....	138-139
costs of	140
high-pressure showering.....	140
performance requirements	139
seaming	139
press felt suction boxes	140
press impulse	115
pressing	
economy of	137
effect on paper quality.....	118-119, 143
future developments	143-146
hot	130-133
press rolls	
antideflexion.....	123-125
ceramic	126
composite covered	126
elastomeric covered	110-111
granite.....	125
grooved.....	112
suction	108-109
press sections	

with shoe presses	119-122
with two nips	127
with three nips	127-128
with four nips	129
profile control	
basis weight.....	19
moisture	195
pulsation dampening	17

R

reel	212-213
refiner, machine	5
rewetting in press nips.....	107
roll-blade former.....	81-82
roll former	75-77
roll former drainage.....	76-77, 97

S

screen plates.....	11
screens	10-11
scrubber for dryer hood exhaust.....	187-188
shadow marking	143
sheet flutter	173-174
sheet shrinkage	181-182
sheet transfer (see wet web transfer)	
shoe press.....	116-122
effect on quality	118-119
principle.....	116-118
short circulation.....	3-4
single-felting for drying.....	175-181
size press	
film	201-204
traditional.....	200-201
slice	19-20
slice bar	19-20
soft calender	208-209
soft calendering process.....	209-212
steam and condensate	
flow control	162-163
systems	160, 163-165
steam, blow-through.....	160-161
steam boxes in pressing.....	130-131
steam economy in drying	182-183
step diffusors (in headboxes).....	14-15
stock flow control	6
stretch roll	54-55
stuff box.....	5
suction boxes	
dry	44-45
on press felts	140
wet	44
suction box seal pit.....	45, 62
suction press	108-109
suction rolls.....	108-109
suction roll shells.....	109-111
supercalendering.....	211-212

"Paper Machine Design and Operation--Descriptions and Explanations" By Gunnar Gavelin

surge tank.....	17
syphon (for condensate removal)	
dimensions.....	169
rotating.....	166-167
stationary	167-168
yankee dryer	168-169

T

table rolls.....	42
take-off angle (from press rolls)	135-136
thermo compressor dryer section.....	163-165
thermo roll (in calendering)	206-207
through drying.....	191
tissue machine formers.....	103-104
transfer belt	120, 137
turbulence generator	
in dryers.....	159-160
in headbox	18
twin wire formers	72-94
two sided drainage, theory of.....	95
two sidedness of paper,	
problems of.....	84

V

vacuum pumps	
turbo compressor	142-143
water ring	140-141
Valmet	
Crescent Former	104
C-Wrap Former.....	103
impingement drying module	189-190
Optireel.....	212-213
Periformer Nouveau.....	104
Speed Former.....	85-86
Speed Former MB.....	86-87
Sym-Flo headbox.....	100
Sym-Former.....	77-79
Sym-Sizer	201-202
Vac Roll dryer section	178-180
Valroc press roll	126
Ventilation	
of dryer hoods	183-187
of dryer pockets	172-174
ventilation fans	
variable speed control	187
Voith	
DuoCleaner.....	172
Duoformer CFD.....	91-93
DuoFormer CV	88
DuoFormer D	80-81
DuoStabilizer dryer section.....	180
GR press roll.....	126
Jet cleaner	60-61
Module Jet	23-25
Top Duo Run dryer section.....	180-181

W

water ring vacuum pump.....	140-141
heat recovery.....	141-142
web transfer	
closed.....	137
open	134-136
wet suction box	44
wet web strength	1, 135
white water	
cleaning, internal	64-66
filters	64-65
flotation	65-66
system.....	3-5
system closure.....	69-70
tanks.....	63
wire (see forming fabric)	
wire pit	63
wire retention	68
wire turning roll.....	49

Y

yankee cylinder	151
yankee hood	152