COMPARAÇÃO DOS PROCESSOS DE COZIMENTO

Celso E.B.Foelkel
RIOCELL

SEMANA DE ATUALIZAÇÃO EM PASTAS QUÍMICAS
São Paulo - 08 a 11.05.95

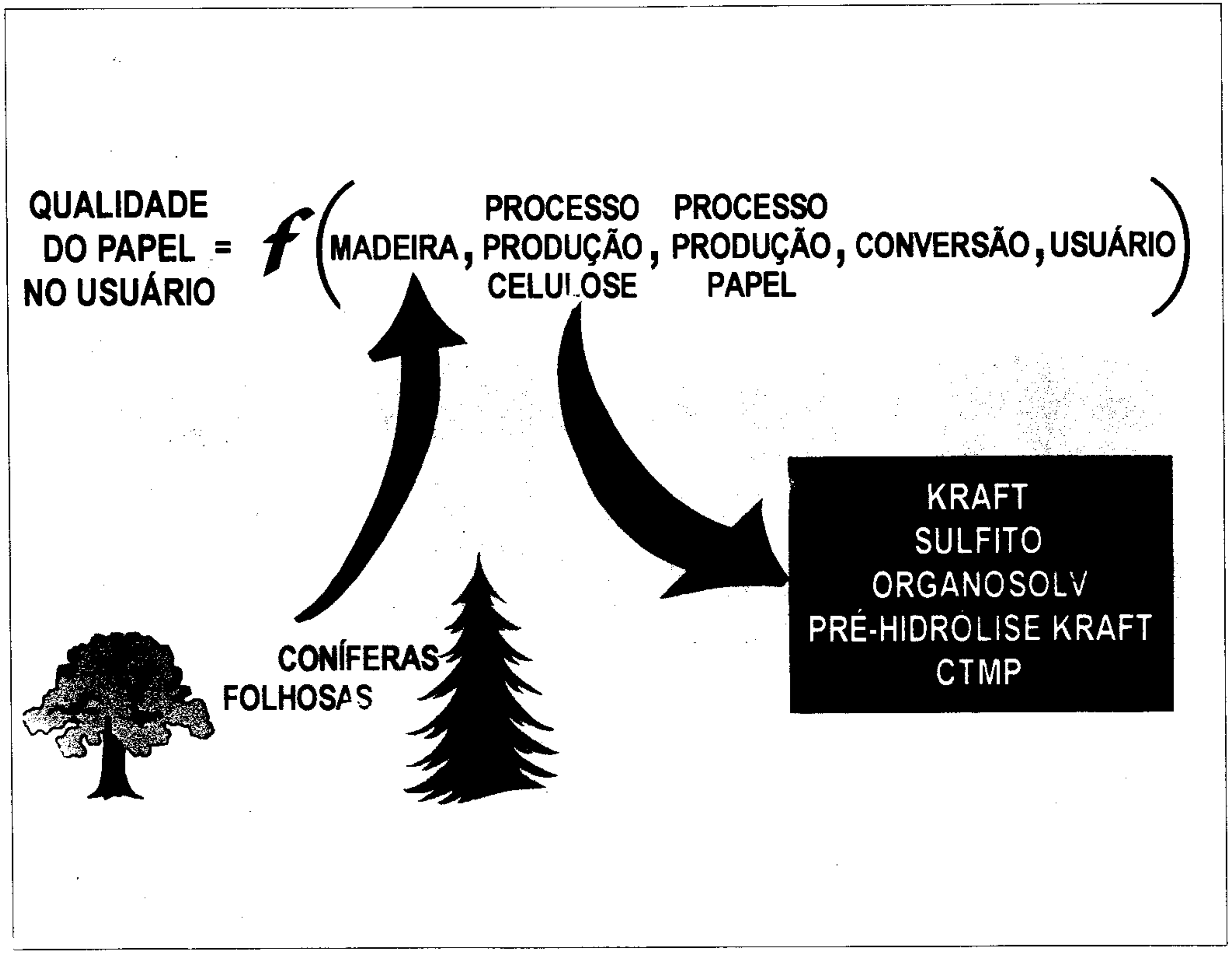

QUALIDADE DO PAPEL NO USUÁRIO = f (MADEIRA, PROCESSO PRODUÇÃO CELULOSE, PROCESSO PRODUÇÃO PAPEL, CONVERSÃO, USUÁRIO)
CONÍFERAS
FOLHOSAS
KRAFT
SULFITO
ORGANOSOLV
PRÉ-HIDRÓLISE KRAFT
CTMP

Table 6.7. Fiber dimensions, hemicelluloses and paper properties of unbleached chemical pulps, made from different wood species by different processes

Wood species	*Picea abies*	*Betula verrucosa*	*Eucalyptus saligna*	*Pinus silvestris*	*Pseudotsuga taxifolia*	*Betula verrucosa*	*Eucalyptus saligna*
Pulping process	Sulfite	Sulfite	Sulfite	Kraft	Kraft	Kraft	Kraft
Pulp yield, %	52	53	54	47	47	53	54
Fiber dimensions of wood							
Length, mm	3.5	1.1	1.0	3.0	3.4	1.1	1.0
Width, μ	27	20	13	28	37	20	13
Wall thickness, μ	2.4	1.8	1.4	3.2	4.0	1.8	1.4
Fiber length of pulp, mm	2.6	1.0	1.0	2.6	2.6	1.0	1.0
Hemicellulose content, %							
Glucomannan	12	4	4	8	12	<1	<1
Glucuronoxylan	5	17	7	13	7	27	15
Paper properties on Valley beating to							
25°SR Beating time, min	10	7	11	51	55	16	10
Tensile strength, km	8.3	5.7	3.7	9.0	7.6	7.0	6.2
Burst strength	73	45	20	88	77	60	52
Tear strength	90	78	50	121	250	88	114
45°SR Beating time, min	19	17	27	75	74	25	24
Tensile strength, km	9.0	7.5	5.0	9.7	8.2	8.6	10.0
Burst strength	74	59	28	95	83	74	90
Tear strength	83	64	45	108	200	73	108

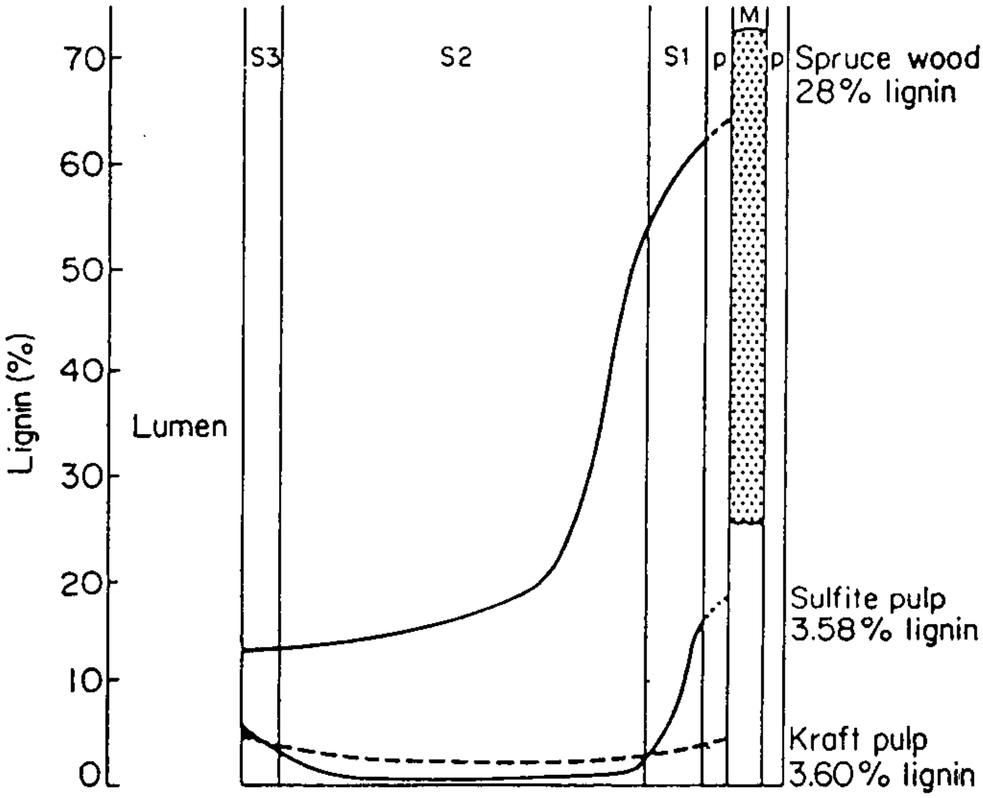


Fig. 6.6. Principal distribution of lignin across the fiber wall of sprucewood, unbleached sulfite and unbleached kraft pulp (Jayme-V. Köppen)

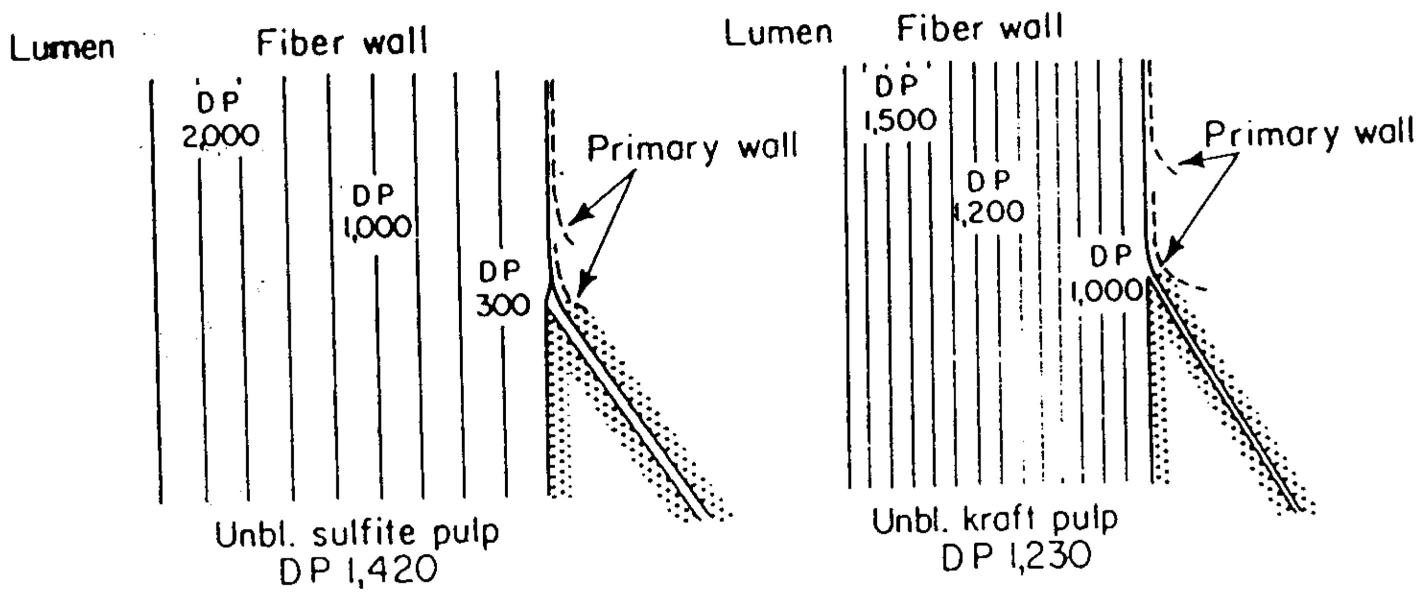


Fig. 6.26. Principal DP distribution across the fiber wall of sulfite and kraft pulp carbohydrates (Jayme–v. Köppen)

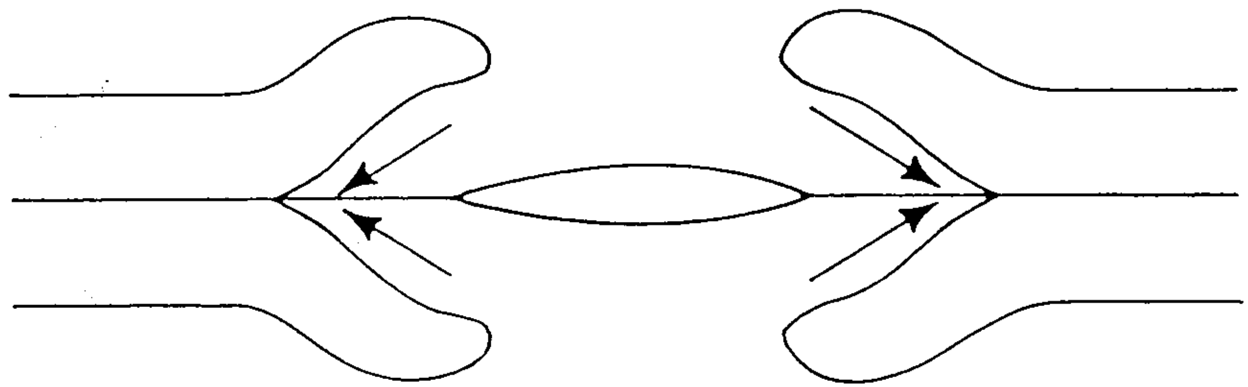


Fig. 6.16. Probable penetration path of sulfite cooking acid (Lange)

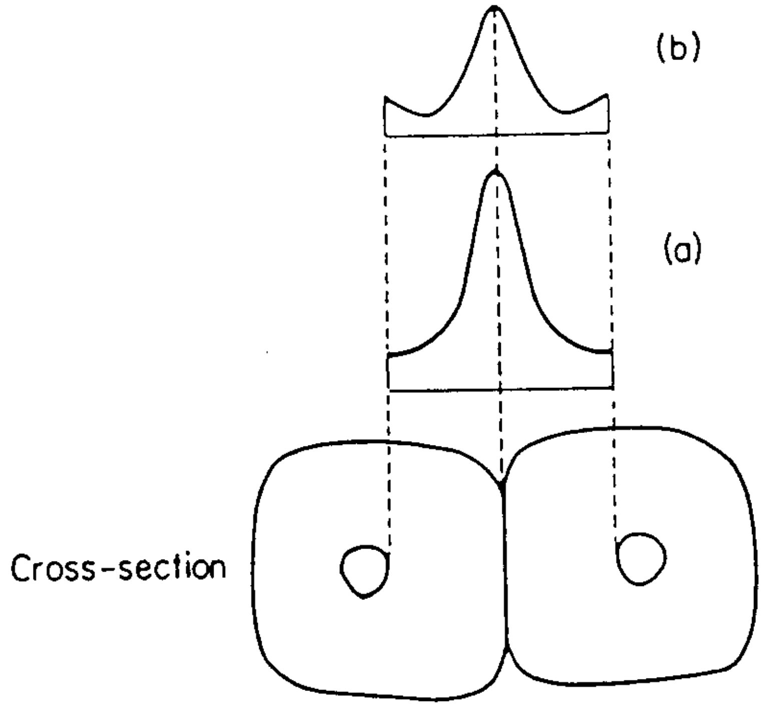
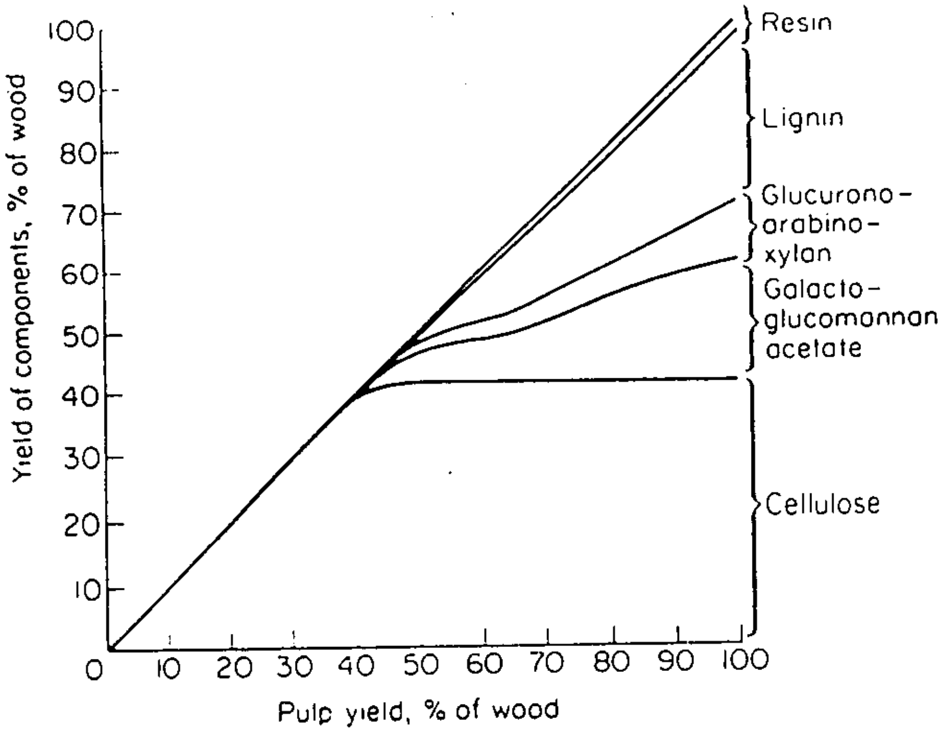


Fig. 6.4. Lignin distribution (a) across the fibers in wood and (b) after partial delignification by sulfite cooking (Lange)



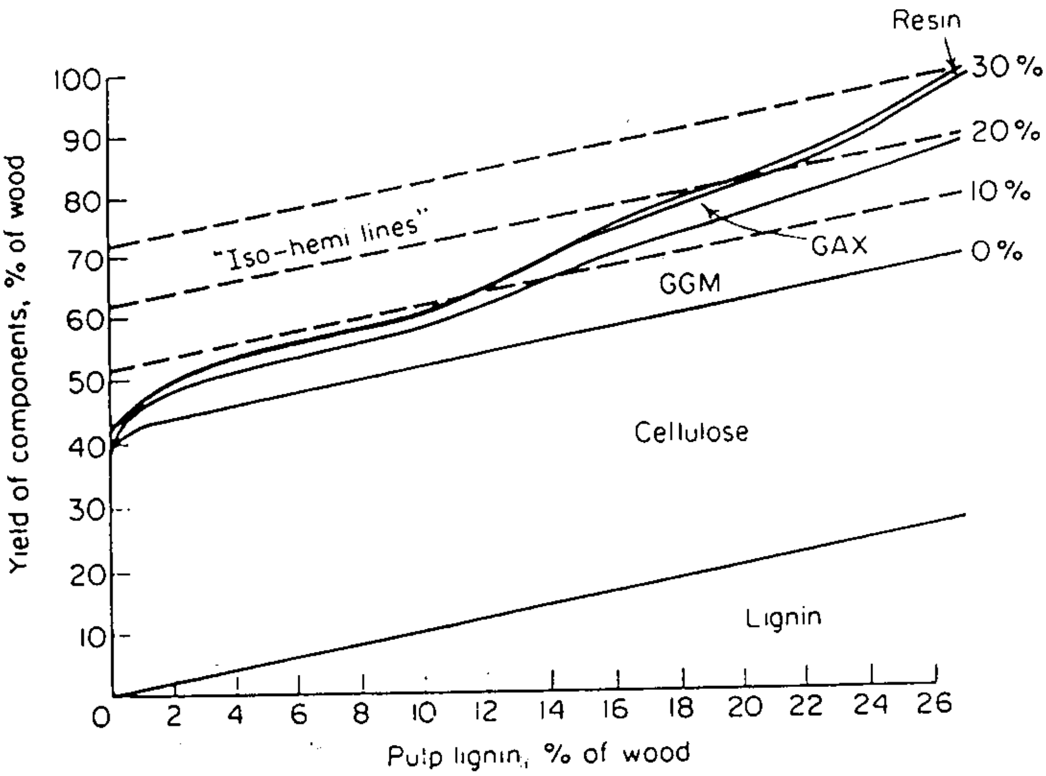


Fig. 6.54. Dissolution of sprucewood components on sulfite pulping. Yield of components as a function of pulp yield or pulp lignin yield. Broken lines indicate constant hemicellulose yield ('iso-hemi lines'), as suggested by Löschbrandt. GAX = glucuronoarabinoxylan, GGM = galactoglucomannan acetate

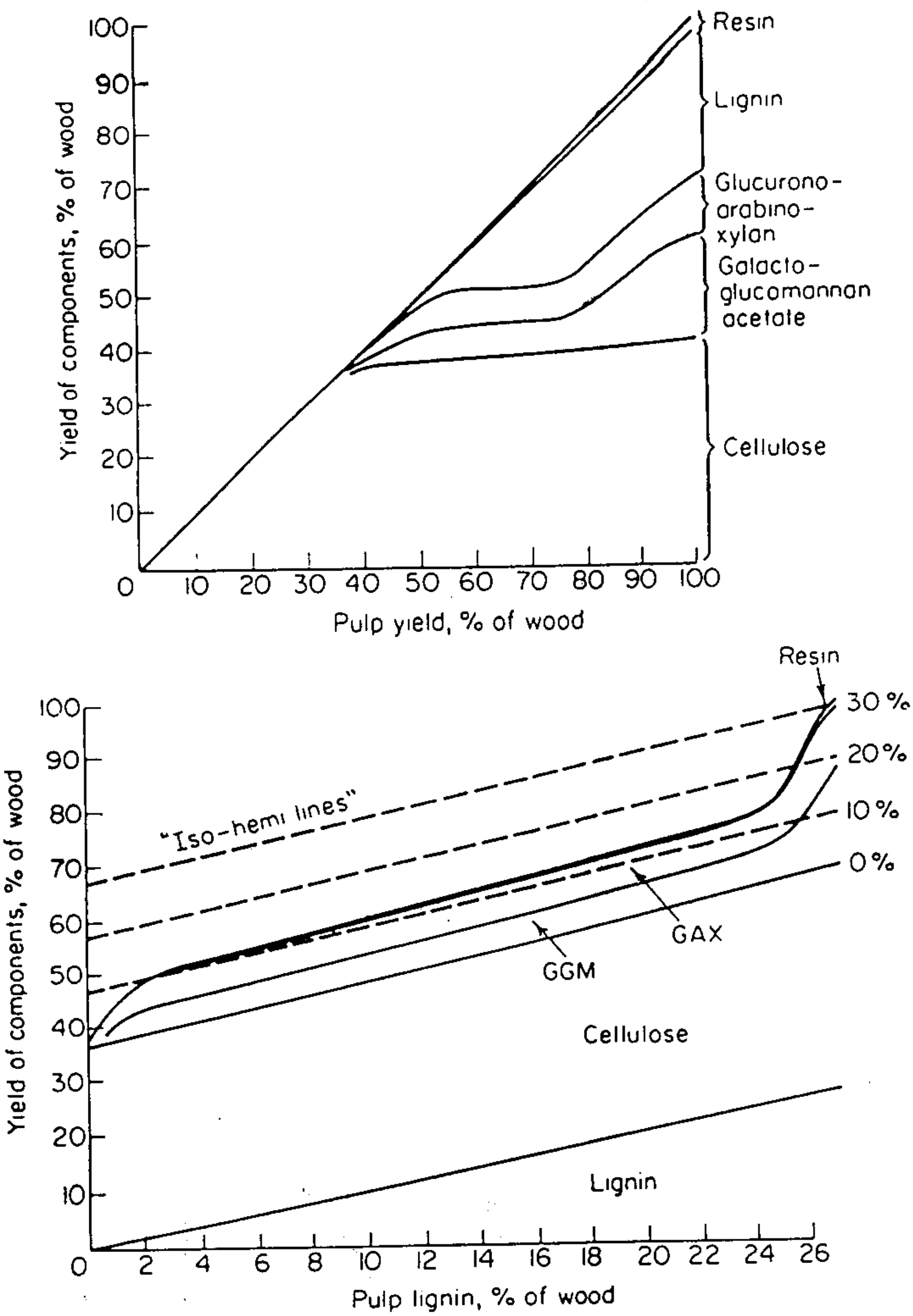
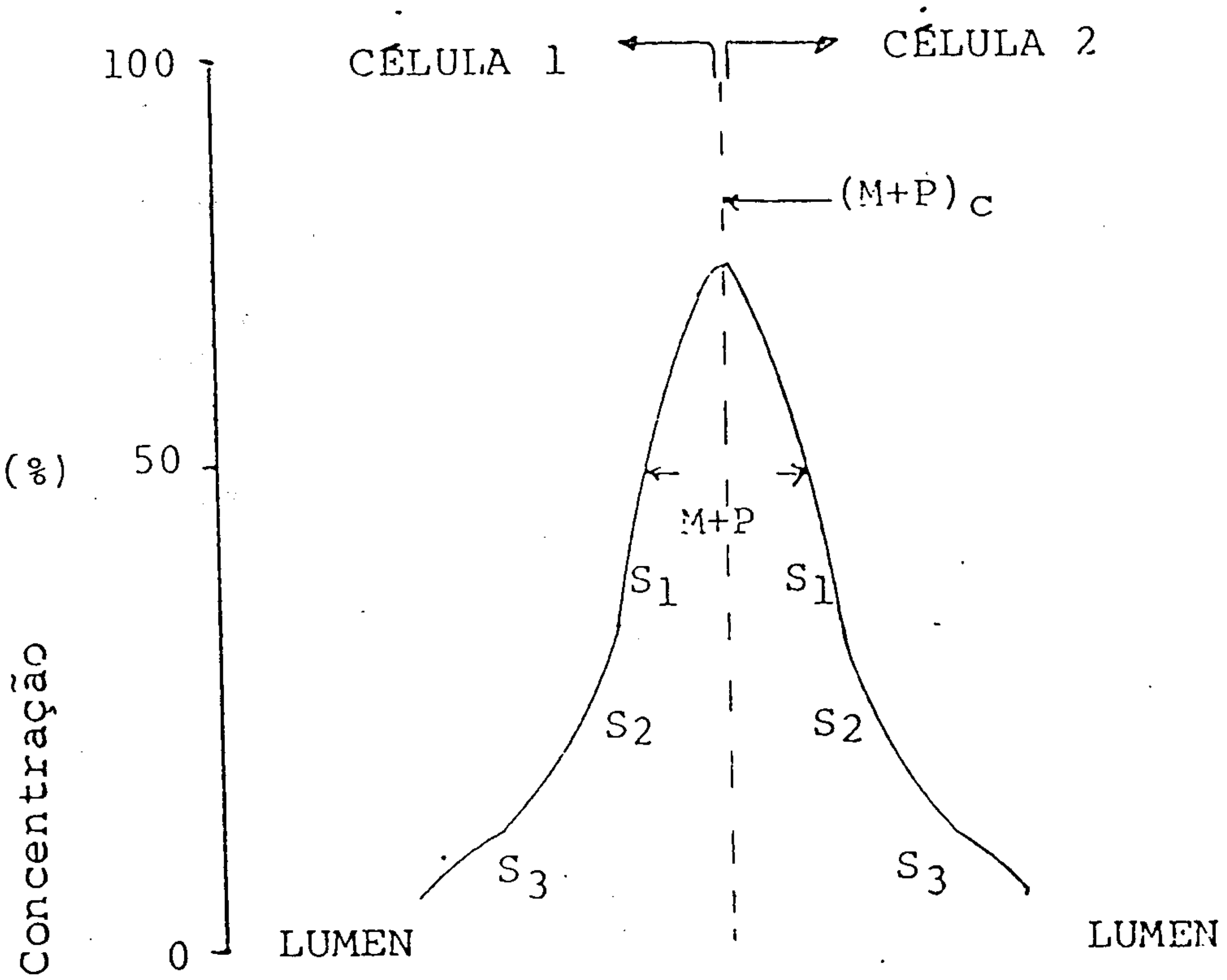


Fig. 6.55. Dissolution of sprucewood components on kraft pulping. Yield of components as a function of pulp yield or pulp lignin yield. GAX = glucuronoarabinoxylan, GGM = galacto-glucomannan acetate

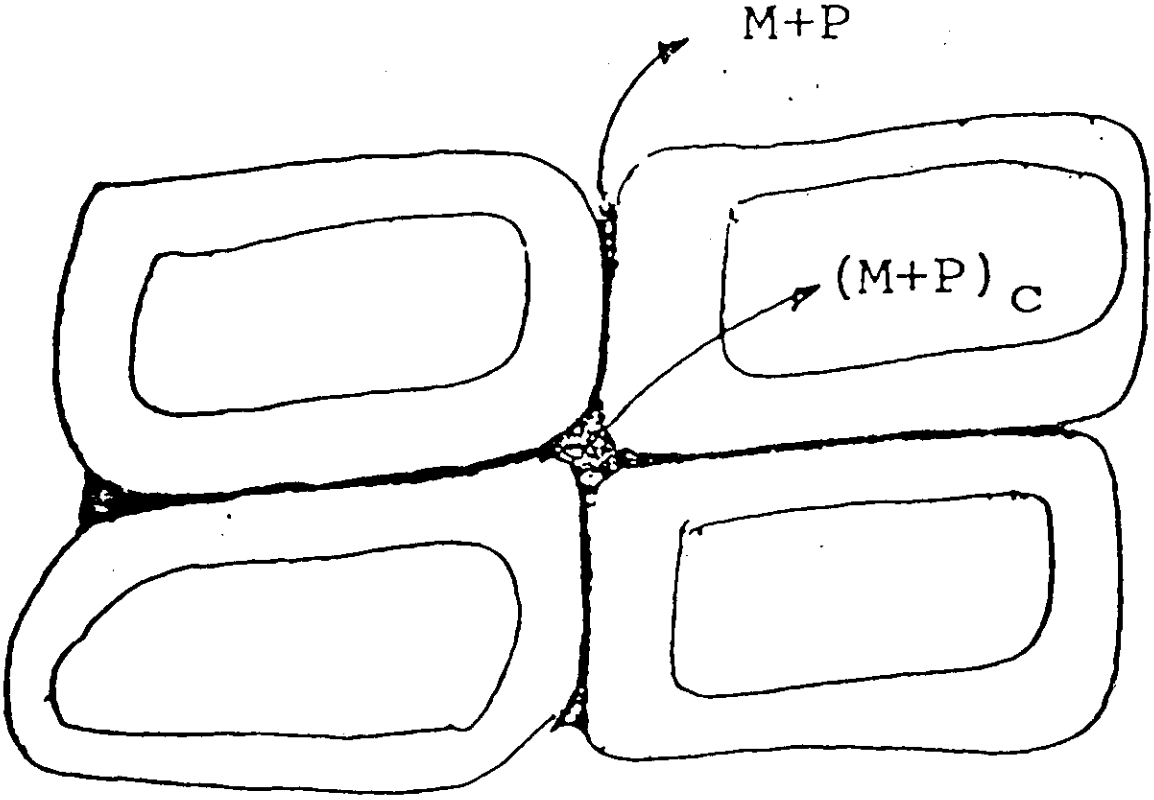
Camada	Celulose (%)	Hemiceluloses (%)
P	10	20
S_1	35	25
S_2	55	30
S_3	55	40

Camada	Concentração
$(M + P)_c$	80 %
$M + P$	50 %
S	25 %
a) S_1	40 %
b) S_2	15 %
c) S_3	5 %



CÉLULA 1
CÉLULA 2
(M+P) C
M+P
S1
S1
S2
S2
S3
S3
LUMEN
LUMEN
100
50
0
Concentração (%)

Lenhos	Inicial			Tardio		
Camadas	(M+P)	$(M+P)_C$	S	(M+P)	$(M+P)_C$	S
Concentração de lignina (%)	50	85	23	60	100	22
% de lignina do total	16	12	72	10	8	82


M+P
(M+P) C

USO DE ANTRAQUINONA

Dimas de Morais
QUÍMICA FINA

SEMANA DE ATUALIZAÇÃO EM PASTAS QUÍMICAS
São Paulo - 08 a 11.05.95

O USO DA AQ
E ALGUNS RESULTADOS
PRÁTICOS NO BRASIL

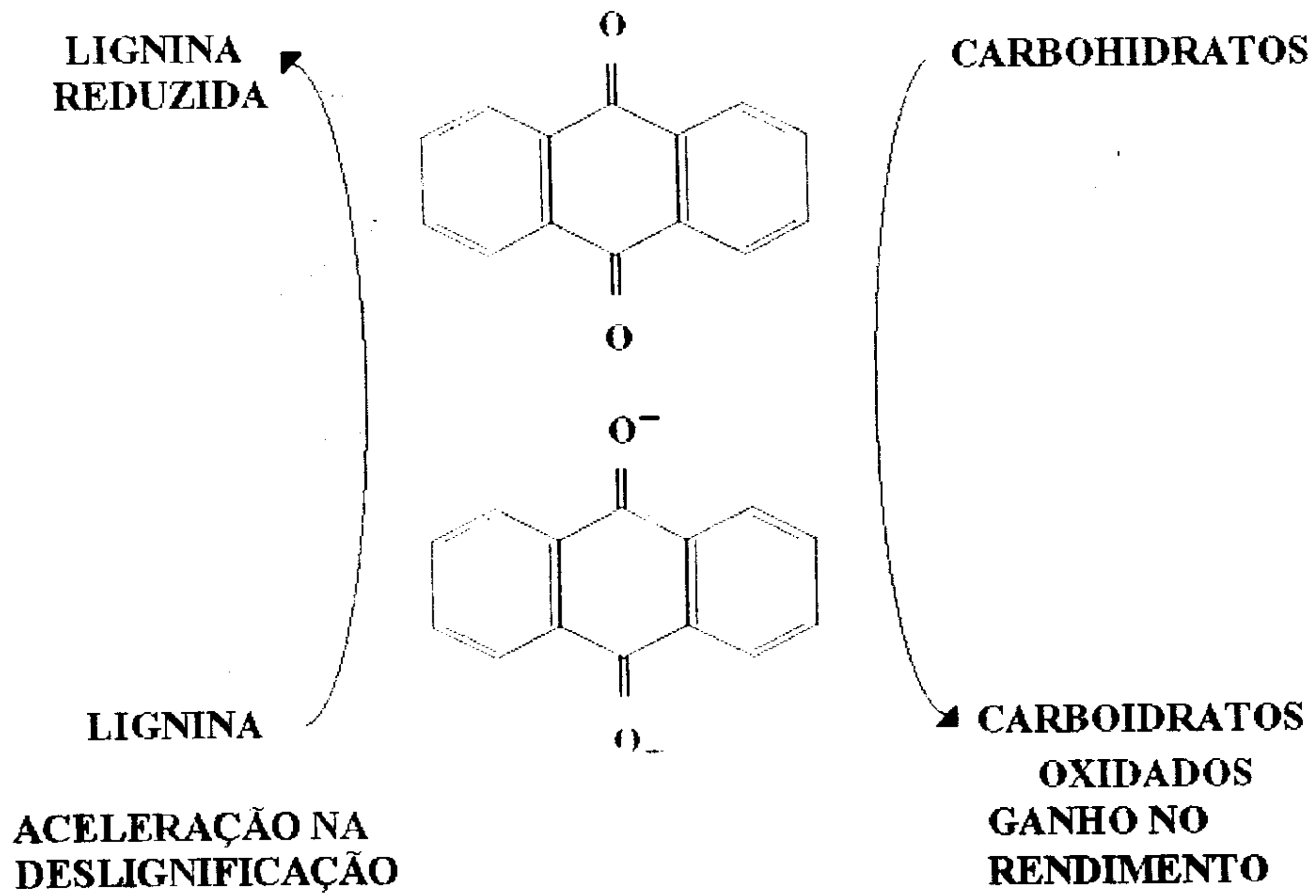
POLPAÇÃO ALCALINA (SODA + ADITIVO)

ADITIVOS ORGÂNICOS E INORGÂNICOS

BASE	ADITIVO	EXEMPLO	PROCESSO
NaOH (soda)	Inorgânico	Na_2S	Kraft
	Orgânico	AQ EDA	Soda + AQ Soda + EDA
	Combinação	AQ + Na_2S	Kraft + AQ

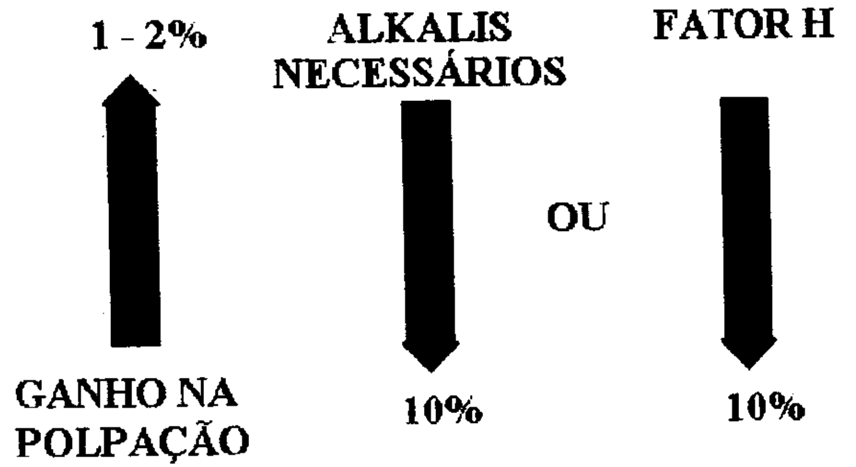
AÇÃO CATALÍTICA DA ANTRAQUINONA

CICLO REDOX



EFEITOS GERAIS DA ANTRAQUINONA NO KRAFT

QUANDO ADICIONADA EM PEQUENAS QUANTIDADES
(0,02% - 0,1% NA MADEIRA)
GERALMENTE PODEMOS VERIFICAR QUE:



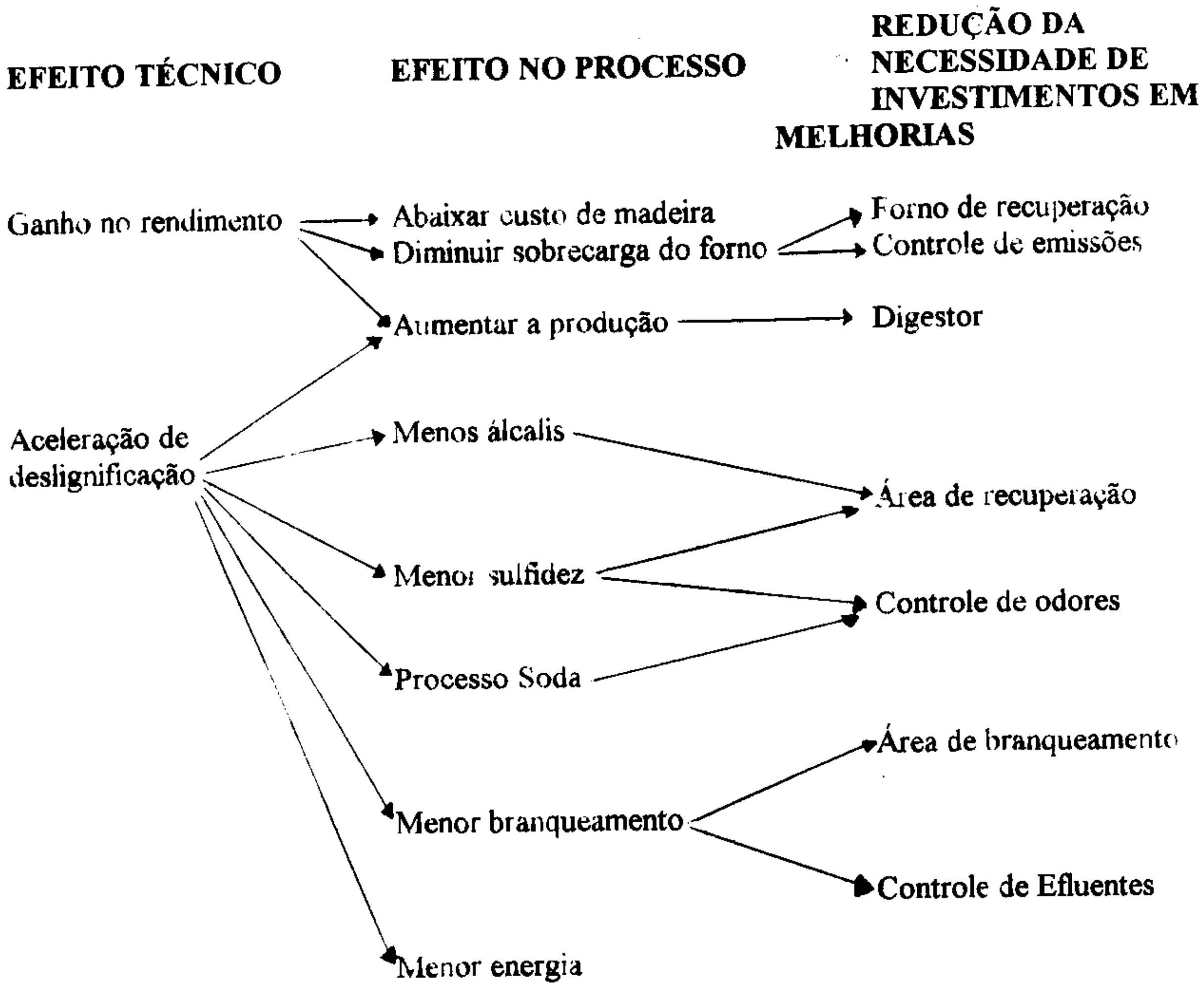
EFEITOS SÃO SENSIVELMENTE MAIORES
NA POLPAÇÃO COM SODA (BAIXA SULFIDEZ)

EFEITO TÉCNICO

GANHO DE RENDIMENTO

ACELERAÇÃO

RESUMO DOS BENEFÍCIOS DA UTILIZAÇÃO DA ANTRAQUINONA COMO ADITIVO DE POLPAÇÃO COM O ESQUEMA A SEGUIR:



SITUAÇÃO ATUAL DO BRASIL COM ANTRAQUINONA

NESTE MOMENTO, 13 EMPRESAS UTILIZAM AQ

OBJETIVOS :

- ***AUMENTO DE PRODUÇÃO***
- ***REDUÇÃO DA SULFIDEZ***
- ***REDUÇÃO DE ÁLCALIS***
- ***LIMITAÇÃO DA RECUPERAÇÃO***

EXEMPLO I - AUMENTO DA PRODUÇÃO

QUADRO 1 - CARACTERÍSTICAS DE PROCESSO KRAFT COM 0,045% DE ANTRAQUINONA

CARACTERÍSTICAS	SEM ANTRAQUINONA	COM ANTRAQUINONA
Média de produção (adt/dia)	193	233
Sulfidez (%)	19	20
Indicador (tss/adt)	1,25	1,13
Alcali ativo (com NaOH)	18,2	15,8
Rendimento por digestor (%)	7,94	8,17
Temperatura cozimento (oC)	171	168
Consumo vapor por cozimento (kg)	11858	10793
Vazão vapor caldeira biomassa (ton/h)	27,40	25,40
Índice de permanganato	30,30	30,70

ICI CANADA FOREST PRODUCTS
ECONOMIC ANALYSIS OF AQ PULPING
MILL DATA REQUIRED FOR ANALYSIS

PULPING PARAMETERS

Furnish (NSW,SSW,WSW,RP,NHW,SHW,EUC)	
Unbleached Pulp Kappa No.	
Effective Alkali (%)	
Sulphidity (%)	
Liquor to Wood Ratio (x:1)	
AQ on Wood OD (%)	

H Factor	
Warm-Up Time (min)	
Cooking Time (min)	
Cool-Down Time (min)	
Blowing / Recharge Time (min)	
Initial Temperature (°C)	
Cooking Temperature (°C)	
Exit Temperature (°C)	

Wood / Pulp Consistency AD (%)	
Unbleached Pulp Yield (%)	
Bleached Pulp Yield (% of unbleached pulp)	
Bleached Pulp Production AD (t/d)	

ENERGY BALANCE (energy / day)

Heat Generated From Recovery Boiler	
Heat Required: Digester	
Evaporator	
Bleach Plant	
Pulp Drier	
Total Daily Electricity Generation (kW•h/d)	
Electricity Requirements: Fixed	
Variable	

How is heat/electricity deficit made up? (Check One)

1) Electricity Purchase	
2) Heat Purchase	
3) Electricity and Heat Purchase	

Heat Derived From Electricity (energy/kW•h)	
Electricity Derived From Heat (kW•h/energy)	

BOILER ANALYSIS (OPTIONAL)

Volatiles lost in digester & evaporator relief gases as % of wood throughput	
Lignin content of wood used (%)	
Resin and fatty acids in wood (RFA) (%)	
Tall oil recovered as % of RFA	
Unbleached pulp washing efficiency (%)	

LIME KILN

Lime Makeup (t/d)	
Lime Kiln Fuel (t/d)	

BLEACH PLANT

Chlorine in C, C/D Stage (t/d)	
Chlorine Dioxide in D0, C/D Stage (t/d)	
NaOH in E1 Stage (t/d)	
Total Bleaching Costs ($/t unbl pulp)	
Adjustment Priority (Cl, ClO2, or both/neither)	

MAKEUP CHEMICALS USED

(In t/d @ Given Conc.)	Conc %	Used (t/d)
Na2SO4		
NaOH		
Spent Acid		
ES		
NaSH		
Na2CO3		
Virgin Acid		
NaHSO3		
NaHSO4		
Na3H(SO4)2		
PSR2000®		
S Derived (as 100%) (t/d)		
Na Derived (as 100%) (t/d)		

MATERIAL AND ENERGY COSTS

	Cost ($/t)
Wood	
Makeup: Na2SO4	
NaOH	
Spent Acid (H2SO4)	
ES	
NaSH	
Na2CO3	
PSR2000®	
Virgin Acid (H2SO4)	
NaHSO3	
NaHSO4	
Na3H(SO4)2	
Lime Kiln Fuel	
Lime	
Chlorine	
Chlorine Dioxide	
Heating Costs ($/unit energy)	
Electricity Costs ($/kW•h)	
Cost of AQ ($/t)	

Price of Surplus Energy ($/kW•h)	
Price of Pulp ($/t)	

COMPANY: ________________

MILL: ________________

AQ APPLICATION CONDITIONS

Digester Limited Mill	
Recovery Furnace Limited Mill	
Alkali Limited Mill	
Constant Chip Throughput	
Constant Pulp Production	

Economic benefit may be achieved through some of the following reductions. Indicate which reductions, if any, are impossible or unacceptable even though financial benefit may result.

Reduce: Kappa No.	
H Factor	
EA	
Sulfidity	

UNITS

Mass: te	
st	
Other (Specify)	
Currency: USD	
CAD	
Other (Specify)	
Energy: GJ (10E9 J)	
10E6 Btu	
Other (Specify)	
Electricity: kW•h	
Other (Specify)	

PLEASE MARK ALL VALUES CLEARLY IF THEY ARE EXPRESSED IN UNITS OTHER THAN THOSE SPECIFIED !!!

NOTES:
NSW = Northern Softwood; NHW = Northern Hardwood
SSW = Southern Softwood; SHW = Southern Hardwood
WSW = Western Softwood; EUC = Eucalyptus
RP = Radiata Pine

COMMENTS:

ICI CANADA FOREST PRODUCTS
ECONOMIC ANALYSIS OF AQ PULPING – CASE A
Bleached Kraft, Digester Limited (H')

ACME Pulp and Paper
1-2-3 Pulp Mill
December 23, 1993

PULPING VARIABLES	Kraft	Kraft-AQ
Furnish	NSW	NSW
Unbleached Pulp Kappa No.	32.0	32.0
Effective Alkali (%)	14.5	14.5
Sulfidity (% of AA)	30.0	30.0
Liquor to Wood Ratio (x:1)	4.0	4.0
AQ on Wood OD (%)	0.00	0.10
AQ Required (st/d)	0.00	2.18
H Factor	1525	1217
Warm-Up Time (min)	60	60
Cooking Time (min)	90	70
Cool-Down Time (min)	30	30
Blowing / Recharge Time (min)	70	70
Initial Temperature (°C)	80	80
Cooking Temperature (°C)	170	170
Exit Temperature (°C)	100	100

PULPING VARIABLE REDUCTION OPTIONS:
Check 'Y' or 'N' for any combination of options

Kappa (K)	N
H Factor (H)	Y
EA (A)	N
Sulfidity (S)	N

PRODUCTION PARAMETERS	Kraft	Kraft-AQ
Wood / Pulp Consistency AD (%)	90	90
Wood Throughput AD (st/d)	2245	2422
Wood Throughput OD (st/d)	2020	2180
Unbleached Pulp Yield (%)	48.0	49.0
Unbleached Pulp Yield Gain (%)		1.0
Unbleached Pulp Production AD (st/d)	1078	1187
Bleached Pulp Yield (% of unbleached pulp)	92.8	92.8
Bleached Pulp Production AD (st/d)	1000	1102
Wood Consumption Ratio AD (KAQ:K)		1.08
Unbleached Pulp Production Ratio AD (KAQ:K)		1.10
Bleached Pulp Production Ratio AD (KAQ:K)		1.10
Increased Heat Load on Boiler (%)		6.5

ENERGY BALANCE	Kraft	Kraft-AQ
Heat Generated from Recovery Boiler (10E6 Btu/d)	7500	7990
Heat Required (10E6 Btu/d): Digester	1327	1432
Evaporator	2000	2158
Bleach Plant	1000	1102
Pulp Drier	2500	2754
Excess Heat (10E6 Btu/d)	673	544
Total Daily Electricity Generation (kW•h/d)	400	323
Electricity Required: Fixed (kW•h/d)	200	200
Variable (kW•h/d)	100	110
Excess Electricity (kW•h/d)	100	13
Extra Electricity Requirements (kW•h/d)	0	0
Extra Heat Requirements (10E6 Btu/d)	0	0

Deficit heat/electricity supplied by (Check "Y" for one box and "N" for the rest):

1) Electricity Purchase	N
2) Heat Purchase	N
3) Electricity and Heat Purchase	Y

Heat Derived From Electricity (10E6 Btu/kW•h)	1
Electricity Derived From Heat (kW•h/10E6 Btu)	1

LIME KILN	Kraft	Kraft-AQ
Lime Makeup (st/d)	22.70	24.49
Lime Kiln Fuel (st/d)	34.00	36.69

BLEACH PLANT	Kraft	Kraft-AQ
% Substitution	68.38	69.48
Chlorine in C, C/D Stage (st/d)	20.00	20.00
Chlorine Dioxide D0, C/D Stage (st/d)	16.00	17.30
NaOH in E1 Stage (st/d)	10.00	11.02

Adjustment Priority
Check 'Y' or 'N' for any combination of options

Chlorine	N
Chlorine Dioxide	Y

Bleached Pulp (Check 'Y' or 'N') Y

ICI CANADA FOREST PRODUCTS
ECONOMIC ANALYSIS OF AQ PULPING – CASE A
Bleached Kraft, Digester Limited (H')

ACME Pulp and Paper
1–2–3 Pulp Mill
December 23, 1993

MAKEUP CHEMICALS

(In st/d @ Given Conc)		Kraft			Kraft–AQ		
	Conc %	Used (st/d)	S Derived	Na Derived	Used (st/d)	S Derived	Na Derived
Na2SO4	100	14.18	3.20	4.59	15.30	3.45	4.95
NaOH	100	31.16	0.00	17.91	33.82	0.00	19.33
Spent Acid	100	31.60	10.40	0.00	34.31	11.22	0.00
ES	100	0.00	0.00	0.00	0.00	0.00	0.00
NaSH	100	0.00	0.00	0.00	0.00	0.00	0.00
Na2CO3	100	0.00	0.00	0.00	0.00	0.00	0.00
PSR2000®	100	0.00	0.00	0.00	0.00	0.00	0.00
Virgin Acid	100	0.00	0.00	0.00	0.00	0.00	0.00
NaHSO3	100	0.00	0.00	0.00	0.00	0.00	0.00
NaHSO4	100	0.00	0.00	0.00	0.00	0.00	0.00
Na3H(SO4)2	100	0.00	0.00	0.00	0.00	0.00	0.00
Totals (st/d)			13.60	22.50		14.67	24.28

BLEACHING COSTS

	Kraft	Kraft–AQ
Total Bleaching Costs (USD/st unbl. pulp)	$32.50	$32.69
C, C/D, D0 Stage Costs (USD/st unbl. pulp)	$16.70	$17.10
E1 Stage Costs (USD/st unbl. pulp)	$2.76	$2.78
Subsequent Stages (USD/st unbl. pulp)	$13.03	$13.01

	Unit Cost (USD/st)	Total Daily Costs (000)	
		Kraft	Kraft–AQ
C, C/D, D0 Stage Costs: Chlorine	$150.00	$3.0	$3.0
Chlorine Dioxide	$1,000.00	$15.0	$17.3
E1 Stage Costs: NaOH	$300.00	[illegible]	[illegible]
Subsequent Stages		$14.0	$15.4
Total Bleaching Costs		$35.0	$39.0

DAILY MATERIAL AND ENERGY COSTS (Thousands USD / Day)

	Unit Cost (USD/st)	Total Daily Costs (000)	
		Kraft	Kraft–AQ
Wood	$150.00	$336.7	$363.4
Makeup: Na2SO4	$160.00	$2.3	$2.4
NaOH	$300.00	$9.3	$10.1
Spent Acid (H2SO4)	$50.00	$1.6	$1.7
ES	$250.00	$0.0	$0.0
NaSH	$785.00	$0.0	$0.0
Na2CO3	$40.00	$0.0	$0.0
PSR2000®	$175.00	$0.0	$0.0
Virgin Acid (H2SO4)	$125.00	$0.0	$0.0
NaHSO3	$79.00	$0.0	$0.0
NaHSO4	$130.00	$0.0	$0.0
Na3H(SO4)2	$92.00	$0.0	$0.0
Lime Kiln Fuel	$120.00	[illegible]	$4.4
Lime	$52.50	$1.2	$1.3
Heating Costs (USD/10E6 Btu)	$0.13	$0.0	$0.0
Electricity Costs (USD/kW•h)	$0.13	$0.0	$0.0
Sale of Electricity (USD/kW•h)	$0.13	($0.0)	($0.0)
Total Bleaching Costs		$35.0	$39.0
Total Variable Costs (Thousands USD / day)		$390.2	$422.4

DAILY NET ECONOMIC BENEFIT (Thousands USD / Day)

	Unit Cost (USD/st)	Total Daily Costs (000)	
		Kraft	Kraft–AQ
Price of Pulp (USD/st)	$500.00		
Cost of AQ (USD/lb)	$1.95		
Product Value		$500.0	$550.8
Total Costs		$390.2	$422.4
Added Value (Value – Costs)		$109.8	$128.4
Difference From Kraft			$18.7
Cost of AQ (Thousands USD/d)			$8.5
Net Daily Benefit (Thousands USD/d)			$10.1

Net Annual Benefit (Thousands USD/A) **$3,552**

Executive Summary

Company:	ACME Pulp and Paper
Mill:	1–2–3 Pulp Mill
Date:	December 23, 1993
Furnish:	Northern Softwood

Comments: Bleached Kraft, Digester Limited (H')

AQ Charge (% on wood)	0.10%
AQ Price (USD/lb)	$1.95
Pulp Price (USD/st)	$500
Bleached Pulp Production Increase	10.2%
Net Benefit (USD/st bleached pulp)	$9.21

Net Annual Benefit (Thousands USD/A)	$3,552

LIMITAÇÃO DA RECUPERAÇÃO (EXEMPLO II)

POLPA DE PINOS COM ANTRAQUINONA A 26% DE SULFIDEZ

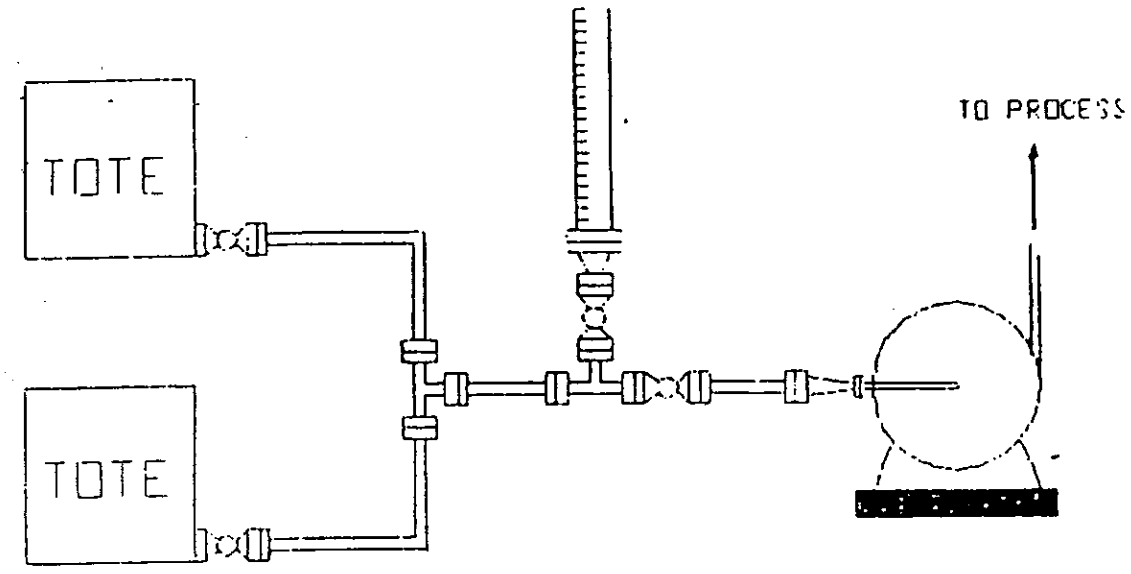
Carga da Antraquinona % sobre madeira	% A.A.	.% E.A	Ganho rendimento	Aumento de produção / constante sólido	Aumento da carga de calor, na caldeira
kappa 22					
0,00	22,40	19,49	-	-	-
0,025	21,84	19,00	+ 0,5%	+ 3,0%	+ 1,0%
0,050	21,60	18,80	+ 0,7%	+ 4,2%	+ 1,5%
0,075	21,38	18,60	+ 0,9%	+ 5,2%	+ 1,9%
0,10	21,25	18,49	+ 1,0%	+ 6,1%	+ 2,2%

LIMITAÇÃO DA RECUPERAÇÃO (EXEMPLO II)

POLPA DE PINOS COM ANTRAQUINONA A 26% DE SULFIDEZ

Carga da Antraquinona % sobre madeira	% A.A.	% E.A	Ganho rendimento	Aumento de produção / constante sólido	Aumento da carga de calor, na caldeira
KAPPA 40					
0,00	20,00	17,40	-	-	-
0,025	18,85	16,40	+ 0,5 %	+ 4,5 %	+ 2,3 %
0,050	18,28	15,90	+ 0,7 %	+ 6,5 %	+ 3,4 %
0,075	17,82	15,50	+ 0,9 %	+ 8,2 %	+ 4,2 %
0,10	17,47	15,20	+ 1,0 %	+ 9,6 %	+ 4,9 %

TRIAL EQUIPMENT SETUP



LIMITAÇÃO DA RECUPERAÇÃO (EXEMPLO II)

POLPA DE PINOS COM ANTRAQUINONA A 26% DE SULFIDEZ

Carga da Antraquinona % sobre madeira	% A.A.	% E.A	Ganho rendimento	Aumento de produção / constante sólido	Aumento da carga de calor, na caldeira
kappa 22					
0,00	22,40	19,49	-	-	-
0,025	21,84	19,00	+ 0,5%	+ 3,0%	+ 1,0%
0,050	21,60	18,80	+ 0,7%	+ 4,2%	+ 1,5%
0,075	21,38	18,60	+ 0,9%	+ 5,2%	+ 1,9%
0,10	21,25	18,49	+ 1,0%	+ 6,1%	+ 2,2%

EXEMPLO I - AUMENTO DA PRODUÇÃO

QUADRO 1 - CARACTERÍSTICAS DE PROCESSO KRAFT COM 0,045% DE ANTRAQUINONA

CARACTERÍSTICAS	SEM ANTRAQUINONA	COM ANTRAQUINONA
Média de produção (adt/dia)	193	233
Sulfidez (%)	19	20
Indicador (tss/adt)	1,25	1,13
Alcali ativo (com NaOH)	18,2	15,8
Rendimento por digestor (%)	7,94	8,17
Temperatura cozimento (oC)	171	168
Consumo vapor por cozimento (kg)	11858	10793
Vazão vapor caldeira biomassa (ton/h)	27,40	25,40
Índice de permanganato	30,30	30,70

LIMITAÇÃO DA RECUPERAÇÃO (EXEMPLO II)

POLPA DE PINOS COM ANTRAQUINONA A 26% DE SULFIDEZ

Carga da Antraquinona % sobre madeira	% A.A.	% E.A	Ganho rendimento	Aumento de produção / constante sólido	Aumento da carga de calor, na caldeira
KAPPA 40					
0,00	20,00	17,40	-	-	-
0,025	18,85	16,40	+ 0,5 %	+ 4,5 %	+ 2,3 %
0,050	18,28	15,90	+ 0,7 %	+ 6,5 %	+ 3,4 %
0,075	17,82	15,50	+ 0,9 %	+ 8,2 %	+ 4,2 %
0,10	17,47	15,20	+ 1,0 %	+ 9,6 %	+ 4,9 %

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