

State-of-the-Art Review on High Yield Pulping Research in Japan

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1. Introduction

Although the term "high yield pulp" was formerly used to mean high yield chemical pulp, here, pulp of all kinds with yields above 65% will be referred to as "high yield pulp". During the recent years there has been an increasing interest in high yield pulp production from the stand point of resources conservation. Fig. 1 (1) shows the relation between pulping method and pulp yield.

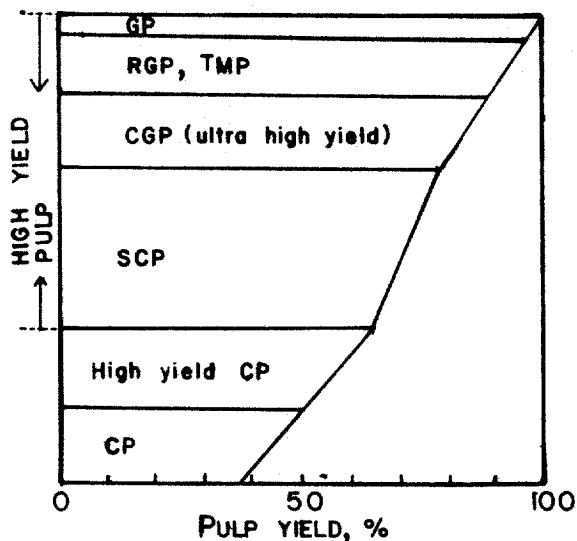


Fig. 1. Pulp yield vs. pulping process

The purpose of this paper is three-fold: to review the growth of high yield pulp production in Japan, to summarize the unsolved problems of high yield pulping and pulp properties, and to look for possible modification of pulp properties.

2. Growth of high yield pulp production

Table 1(2) shows the main developments in the growth of high yield pulp production. It was 100 years ago that the first machine-made paper was produced in Tokyo. At that time, the raw material was mainly cotton rag. The industry has kept growing steadily ever since. Sulfite pulp was produced in 1889, groundwood in 1890 and kraft pulp in 1925.

Table 1. Growth of high yield pulp in Japan

- 1) 1872 Establishment of first paper company
- 2) 1874 Production of machine made paper
- 3) 1889 Production of sulfite pulp (SP)
- 4) 1890 Production of groundwood (GP)
- 5) 1925 Production of kraft pulp (KP)
- 6) 1951 Production of chemiground pulp (CGP, chips)
- 7) 1953 Production of neutral sulfite semichemical pulp (SCP)
- 8) 1964 Production of refiner groundwood (RGP)
- 9) 1975 Production of thermomechanical pulp (TMP)

At first, Japanese engineers improved pulp and paper production under the guidance of foreign engineers. However, in the 1920's, the domestic and foreign techniques were mastered sufficiently and a spirit of independence consequently appeared. In 1951, the first chemiground pulp was produced by the cold-soda process. Neutral sulfite semichemical pulp was produced in 1953, refiner groundwood in 1964 and thermomechanical pulp in 1975.

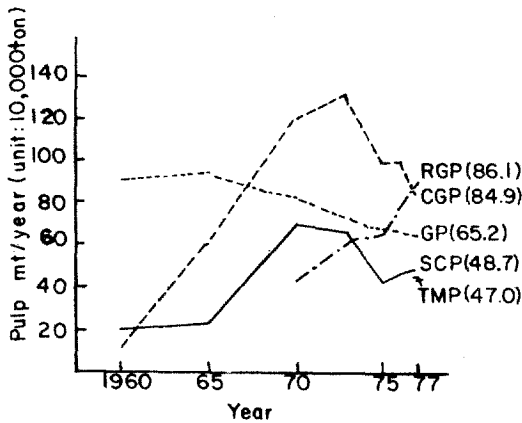


Fig. 2. High yield pulp production 1960—1977
Data in brackets: Production amount, 104 tons/year.

Fig. 2(1) shows the statistics of high yield pulp production from 1960 to 1977. Until very recently, chemiground pulp and semichemical pulp were normally used for newsprint, low or middle grade printing paper, corrugating medium and so on. Maximum annual production of chemiground pulp was in 1973 at 1.32 million tons and of semichemical pulp in 1970 at 0.7 million tons. Since then, however, the production of both pulps has decreased due to the technical problems of effluent treatment and chemical recovery from spent liquor, and due to limited paper properties and bleachability. In addition to the technical problems mentioned above, the recently developed thermomechanical pulp has started to challenge the monopoly of chemiground pulp on newsprint and printing paper. The production of thermomechanical pulp is thought to be about 0.47 million tons in 1977 and 0.72 million tons in 1979.

3. Technical problems in high yield pulp production

Here will be discussed four items: paper strength, fiber bundles, brightness and spent liquor treatment.

3.1 Paper strength

High yield pulp contains more lignin than the conventional chemical pulp. Therefore, refining and beating have little effect on fibrillation of pulp fiber, and the strength of paper therefrom is relatively low. Consequently, a process for making high yield pulp which is easily refined and beaten is desired. In order to increase the paper strength, the promotion of softening of chips is fundamentally important.

3.2 Fiber bundles

Fiber bundles are due to the high lignin content of pulp, and cause the poor paper properties. From the standpoint of printability and appearance, paper containing fiber bundles is far inferior to paper produced from bleached chemical pulp. Even if paper containing fiber bundles is coated with pigments, the fiber bundles are visible through the coated layers after supercalendering.

The reduction of fiber bundles is possible by the promotion of softening of chips and also to some extent by high consistency refining.

3.3 Brightness

The color of high yield pulp is due to wood extractives and lignin (3). The coloration of lignin which affects the color of pulp has been studied in our laboratory (4). Our results are summarized in Table 2. The coloration of lignin is derived from quinoid structures, metal complexes of catechol structures and conjugated structures extending across two or more phenylpropane units.

Table 2. Chromophores in lignin

Lignin	Chelate %	Quinoid %	Conjugated structure, %
MWL	—	100	—
LSA	40 - 50	40	5 - 8
TL	10	35	5 - 8

MWL : milled wood lignin

LSA : lignosulfonate

TL : thioglignin

In order to increase the brightness of high yield pulp, so-called "preservative bleaching" has been widely adopted. As is well-known, there are two types of bleaching, oxidative and reductive. However, reductive bleaching is reversed by air, ultraviolet light and so on. With oxidative bleaching, on the other hand, there is a levelling-off of brightness even though lignin chromophores in the pulp continue to be destroyed, as shown in Fig. 3(5).

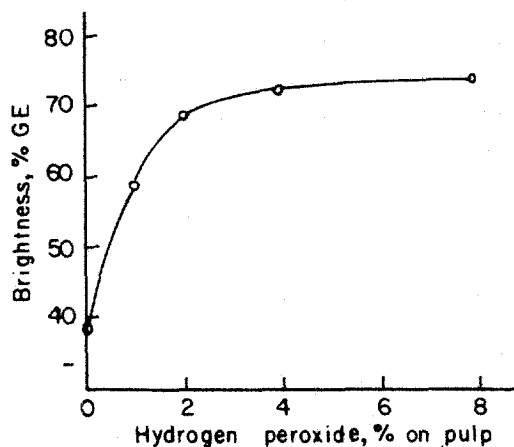


Fig. 3. Brightness vs. amounts of hydrogen peroxide added.

In this case, brightness increases as a result of the competitive reaction between the degradation of lignin chromophores and secondary formation of chromophores and further transformation to stable color structure. Such a pulp is not a suitable raw material for paper which requires preservation over a long period. This is why a new bleaching agent or process for high yield pulp is desired.

3.4 Spent liquor treatment

The higher the pulp yield is the lower the solid concentration in spent liquor. The cost of concentrating spent liquor for burning is rather high.

Although various methods of evaporation and burning have been adopted for the recovery of chemicals, there is no definite opinion as to which method is the best. In the case of pulps with higher yield than semichemical pulp, the evaporation of the spent liquor is difficult because of their low solid concentration.

Generally speaking, spent liquor from high yield pulp excepting semichemical pulp tends to be reused in the process as much as possible, and the excess spent liquor is subjected to outside effluent treatments.

4. Directions of research on modification of high yield pulp

The discussion on modification of high yield pulp will be centered on the softening of pulp fiber.

4.1 Modification of mechanical pulp

Groundwood production began in 1890 as shown in Fig. 1. But during the past 90 years, there has been no fundamental change in the grinding process of wood, although the Bersano Grinder (Cartiere Burgo, Italy) (6) based on a different mechanism from the stone grinder was proposed in 1960. Recently, thermomechanical pulp defiberized around the softening temperature of lignin, about 120°C, has been worthy of comment among the pulp and paper industries of the world.

There is some limit on paper strength in the case of mechanical pulps, because pulp constituents are similar to wood constituents. In order to increase paper strength, the post-treatment of pulp is required. The fundamental idea of post-treatment is to enhance the hydrophilic properties of lignin in pulp. The addition of another material to pulp may also be useful in modifying some paper properties.

Summarizing the previous papers, the post-treatment of pulp with sodium hydroxide (7), sodium sulfite (8), sodium sulfite-sodium hydroxide (9), sodium sulfite-formaldehyde (10) have been tested. The beatability of pulp is accelerated and the paper

strength increased by those post-treatments.

Tsukamoto (9) added 5% sodium sulfite and 1% sodium hydroxide to refiner groundwood and treated it for a short 30 sec. in a flash dryer. As shown in Table 3, this pulp showed an increase of tensile

Table 3. Sheet properties of sulfite treated RGP in flash drier

	Control	Charge of chemicals
Na ₂ SO ₃ , % on B.D. pulp	--	5
NaOH, % on B.D. pulp	--	1
Pulp consistency before drying, %	40	40
Pulp consistency after drying, %	85	85
Degree of sulfonation, mmol/100g pulp	2.9	18.0
CSF, ml	105	115
Bulk density, g/cm ³	0.33	0.36
Breaking length, km	3.70	4.85
Tear factor	85	100
Brightness, % Hunter	47.0	48.0
Opacity, %	96.7	95.6

strength of 30% and of tear factor of 15% when compared with untreated pulp.

Sodium sulfite-formaldehyde treatment of refiner groundwood causes sulfomethylation at the ortho-position of the phenolic hydroxyl groups of lignin, in addition to the conventional sulfonation at the position of the lignin side chain. This means that

sodium sulfite-formaldehyde treatment of pulp gives more hydrophilicity to lignin than sodium sulfite treatment alone. Fig. 4 shows the sulfonation and sulfomethylation reactions of lignin with sodium sulfite-formaldehyde. Refiner groundwood of CSF 680 ml obtained from the removal of a portion of the fines by a classifier, was treated with sodium sulfite-formaldehyde. The post-treated pulp was easily beaten by a Lampen mill as shown in Fig. 5 and shows a great increase in tensile strength, burst factor and tear factor as shown in Table 4 and 5 (10).

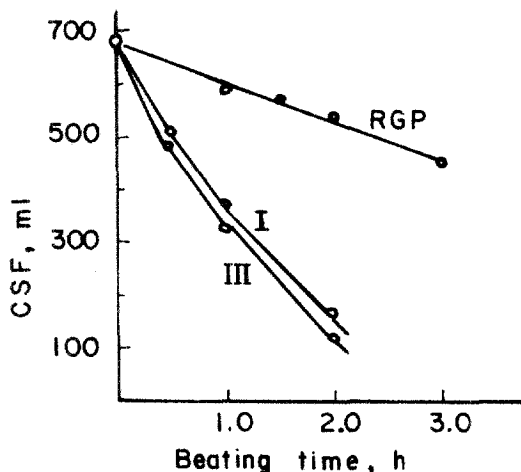
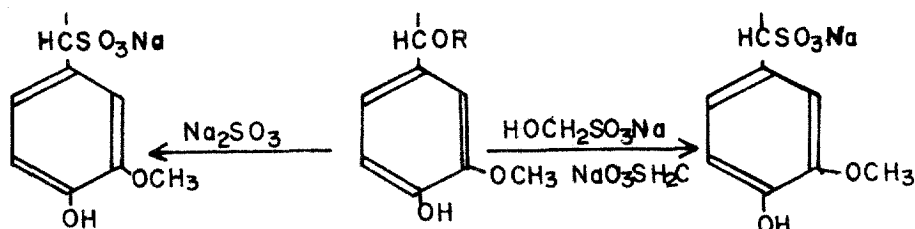


Fig. 5. CSF vs. beating time



R : H, ALKYL, ARYL

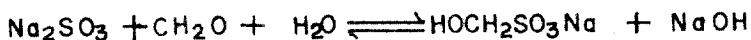


Fig. 4. Sulfonation and sulfomethylation of lignin

There is another type of modification of mechanical pulp, polyethylene coating (11). The porosity of pulp sheet is controlled by the amount of polyethylene. The mechanical properties, however, were poor except for wet strength. The grafting of vinyl monomers onto groundwood was also studied. Although the grafting onto ligninrich pulp is normally difficult with a ceric salt initiator (12); Hatakeyama (13) succeeded in grafting methylmetacrylate and vinyl-sulfonate onto groundwood by the use of an acetic acid-hydrogen peroxide initiator. He did not

Table 4. Cooking results of Larch RGP

Pulp	Cooking temp. °C	pH of Spent Liq.	Yield, %	Klason Lignin, %
Original		(12.7)	100	26.9
I	110	9.4	95.9	24.7
II	130	8.5	92.7	23.6
III	150	7.9	89.1	19.6

Cooking Liq. : (50g Na₂SO₃ + 11g CH₂O)/L

Cooking time : 2.0 hrs

Table 5. Strength properties of Larch RGP handsheet

Pulp	CSF ML	Density g/cm ³	Breaking length, km	Tear factor	Burst factor	MIT folding
Original	680	0.38	1.5	60.2	1.1	3
	330	—	2.2	29.6	1.0	4
I	487	0.59	2.9	52.6	1.4	5
	350	0.62	3.9	35.9	1.5	4
II	469	0.65	3.9	53.0	1.6	4
	347	0.68	4.0	42.5	1.7	13
III	445	0.73	5.1	62.1	2.8	41
	324	0.81	5.6	49.0	2.8	59

mention about the mechanical properties of grafted pulp. Such a treatment with synthetic high polymers may be worthy of notice as one of the possible modification of high yield pulp.

Besides the modification methods mentioned above, groundwood pre-treated with organic solvent shows a 10-18% higher sheet strength than the original groundwood (14). Such an increase of sheet strength is due to the enhancement of inter-fiber bonding by removal of extractives from the pulp.

4.2 Modification of chemiground pulp and semichemical pulp

Here will be discussed chemiground pulp and semichemical pulp with yields of 60-90%. The following kinds of modification may be useful: (a) a new cooking chemical to replace the present one

or (b) a different method for the cooking of chips and the refining of cooked chips.

A novel method for fiber separation was proposed which involved an explosive decompression of chips chemically treated with ammonia at elevated temperatures and pressures (15). The strength properties of this pulp with yields of 89-91% greatly exceed those of conventional mechanical pulp.

However, it is fundamentally important to increase the hydrophilicity of pulp. As shown in Tables 6 and 7 (16), pulp by sodium sulfite-formaldehyde cooking is higher in screened yield, water retention value and brightness, and is more easily beaten than pulp by sodium sulfite cooking alone. Sheet strength of the former is 10-20% higher in tensile strength and burst factor, but lower in tear factor than the latter, as shown in Table 8 (16).

Table 6. Cooking results of spruce, beech, oak and white birch

Pulp No.	Cooking liquor		Cooking condition		Total yield, %	Screened yield, %	Brightness %	
	Na ₂ SO ₃ g/l	CH ₂ O	Max. temp.	Time. min.				
Spruce	1	20		160	60	90.5	68.7	31.6
	2	20	+	160	60	90.0	74.5	34.9
	3	30		160	60	87.7	74.7	34.8
	4	30	+	160	60	87.1	76.3	38.6
	5	40		160	40	87.6	72.8	36.0
	6	40	+	160	40	87.1	74.3	38.8
	7	50		160	40	88.2	74.1	36.8
	8	50	+	160	40	88.0	76.6	38.8
Beech	9	30		150	120	88.3	67.6	47.5
	10	30	+	150	120	88.6	69.9	49.6
	11	40		150	120	88.0	67.3	—
	12	40	+	150	120	88.2	67.6	—
	13	50		150	120	86.9	68.4	43.4
	14	50	+	150	120	87.5	68.5	44.9
Oak	15	40		150	60	84.1	56.6	44.4
	16	40	+	150	60	83.9	58.2	48.9
	17	40		150	120	83.8	51.5	—
	18	40	+	150	120	81.6	52.2	—
White birch	19	30		150	120	85.2	55.0	47.6
	20	30	+	150	120	84.4	56.7	48.3
	21	40		150	120	85.2	56.2	47.9
	22	40	+	150	120	85.4	57.8	49.6
	23	50		150	120	85.8	57.0	46.3
	24	50	+	150	120	85.3	61.6	49.8

+ : Equimolar addition to Na₂SO₃

Chemiground pulps soaked in acetic acid, propionic acid, metacrylic acid and vinylsulfonate, respectively, were irradiated with γ -ray. Compared with untreated pulp, irradiated pulp were more easily beaten and showed a increase of tensile strength of 10% with 2 Mrad irradiation. Five Mrad irradiation of soaked pulp reversely caused the decrease of tensile strength. This is attributed to the decomposi-

tion of wood fiber by γ -ray irradiation (17).

In alkaline cooking, the addition of anthraquinone and its derivatives has been observed to accelerate delignification and result in the increase of pulp yield. Consequently, there have been many papers and patents in the field of alkaline cooking. Nomura (18) reported that anthraquinone promotes the homogeneous softening of chips in neutral sulfite

Table 7. Analytical data of screened pulp

Pulp No.		Kappa number	SO ₃ Na mmole/100 g Pulp	Water retention * value. %
Spruce	3	118.3	—	78.8
	4	115.5	—	82.6
	5	115.2	—	81.0
	6	110.6	—	87.8
White birch	19	94.1	24.7	54.1
	20	93.6	27.3	63.9
	21	96.6	31.0	62.4
	22	95.7	32.8	67.3
	23	105.6	30.6	81.3
	24	98.2	31.9	87.9

* Centrifuged at 1,200 rpm for 15 min.

or sodium carbonate cooking and results in the decrease of consumption of refining energy and the increase of paper strength.

Recently, a thermomechanical pulp modified by

precooking with sodium sulfite, has come to be produced. In this connection, chemithermomechanical pulp from sodium sulfite-formaldehyde treatment may be worth studying.

One mill in Japan is now using a new refining method which uses 0.5-1.0% sodium hydroxide. As shown in Table 9 (19), such a pulp has no fiber bundles and higher sheet strength than the conventionally refined pulp.

Sakai (20) cooked beech chips with peracetic acid, neutral sulfite and sodium hydroxide, and clarified the relation between the defibration temperature of cooked chips and pulp properties.

As shown in Fig. 6, energy consumption for defibration of cooked chips decreases steadily with increasing defibration temperature in the range of 15 to 90°C, then levels off after 90°C. Untreated chips, however, show little decrease in energy consumption until sudden drop in the range of 120 to 130°C. This means that cooking with the above chemicals promotes the softening of chips and decreases energy

Table 8. Strength properties of spruce and white birch pulp hand sheets

Pulp No.		Beating by PFI mill		Basis wt. g/m ²	Density g/cm ³	Breaking length, km	Tear factor	Burst factor	MIT folding
		Rev.	CSF, ml						
Spruce	1	2,500	535	61.4	0.41	3.25	117.3	2.44	39
	2	2,350	515	62.1	0.43	3.87	103.1	2.65	41
	3	2,800	495	63.8	0.46	3.85	84.6	2.71	69
	4	2,700	505	66.7	0.50	4.00	81.0	3.30	151
	5	3,200	500	67.1	0.51	3.98	80.5	3.35	205
	6	3,100	510	66.4	0.54	4.23	81.9	3.48	357
	7	3,120	500	69.1	0.49	4.69	87.4	3.70	233
	8	3,120	490	64.6	0.49	5.47	83.7	3.97	306
White birch	19	500	485	66.8	0.49	4.30	70.1	2.47	26
	20	300	465	64.3	0.51	4.87	68.1	2.58	26
	21	300	500	68.5	0.49	4.28	75.9	2.58	32
	22	200	505	67.5	0.59	5.13	75.2	2.62	39
	23	250	460	68.0	0.56	4.81	75.9	2.94	59
	24	200	470	67.3	0.55	5.25	71.4	3.06	61

Table 9. Sheet properties of two stage high yield pulp produced at commercial plant

	Two stage high yield pulp (hardwood)			Cold soda (hardwood)	GP (softwood)	BKP (hardwood)
CSF, ml	526	384	254	275	140*	446
Density, g/cm ³	0.53	0.60	0.65	0.56	0.45	0.77
Breaking length, km	2.9	4.11	4.8	2.7	1.8	6.7
Burst factor	1.5	2.2	2.5	1.8	1.1	4.6
Tear factor	56	51	52	52	39	74

* without beating

Table 10(a) Relation between softening method and exposed fiber surface

Softening Method	Wood species	Sample	Exposed fiber surface	Researcher
Heat	Birch	Cross section	Oil 250°C	Stone (1955)
	Spruce	"	Water 190°C: S ₁ -S ₂	Stockman (1957)
	Birch	"	Water 190°C: M-S, S ₁ -S ₂	"
	Spruce	Surface	Glycerine 180°C: M-S	Koran (1967)
	"	"	Water 115°C: S ₁	Attack (1972)
	"	"	Water 150-170°C: M-P	"
	"	"	Water 150°C < : yield 90%, M-P	Sumi (1973)
Cold soda	Spruce	Cross section	NaOH 25g/l: S ₁ -S ₂	Stockman (1957)
	"	"	75g/l: S ₁ -S ₂	"
	Birch	"	25g/l: S ₁ -S ₂	"
	"	"	75g/l: S ₁ -S ₂	"
	Eucalyptus	"	S ₁ -S ₂	Wadrop (1963)
Hot soda	Eucalyptus		0.05% NaOH	Stewart (1961)
	Radiata pine		0.05% NaOH	"
	Poplar	Surface	5% NaOH, 70°C, yield 92.1%: M, S ₁	Azzola (1970)
	"	"	"	"
Kraft	Spruce	Cross section	Yield 60.5-67.4%: M-S ₁	Stockman (1957)
	Birch	"	67.9-74.5%: M-S ₁	"
	Spruce	"	85-90%: S ₁ -S ₂ , partially P-S ₁	Polcin (1967)
	"	Surface	80% > : P-S ₁ > S ₁ -S ₂	"

M : middle lamella, S₁: outer layer of secondary wall.S₂ : middle layer of secondary wall

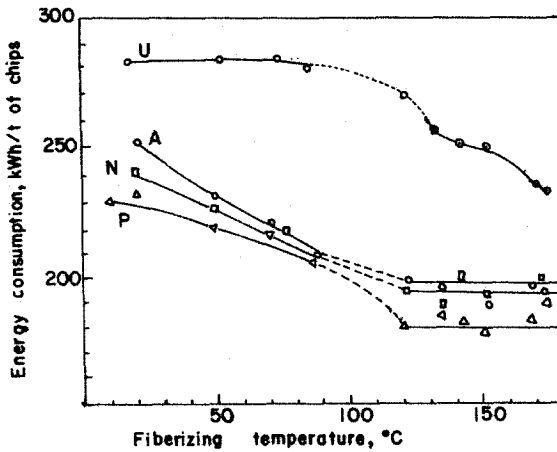


Fig. 6. Energy consumption as a function of the fiberizing temperature.

consumption for defibration. Cooking of chips with peracetic acid followed by defibration at 150°C resulted in the best pulp among those tested. In a subsequent paper Sakai discussed why peracetic acid

is useful as a cooking chemical (21).

4.3 Relation between morphology of fiber surface and sheet strength

It is conceivable that the morphology of the fiber surface of high yield pulp influences the inter-fiber bonding and thus the sheet strength. During the past 20 years, fiber surface which had been exposed by refining of chips cooked with various chemicals or by shearing or tensile loading wood specimen cooked with various chemicals, was observed by an electron microscope, and the relation between fiber surface and sheet strength discussed. There is no definite opinion about the relation between softening chemicals and fiber surface, as shown in Table 10-a and -b (22).

Iwamida found that 30 to 50% of the fiber surface of high yield sulfite pulp which had been refined to the level of full stuff, is covered with secondary wall.

Table 10(b). Relation between softening method and exposed fiber surface

Softening method	Wood species	Sample	Exposed fiber surface	Researcher
Acid sulfite pH1-2	Spruce	Cross section	Yield 75.9%: S ₁ -S ₂	Stockman (1957)
	"	"	62.6-70.9%: M-S ₁	"
	Birch	"	59.7-75.1%: M-S ₁	"
	"	Surface	60-70%: M, 55% >: P, S ₁	Giertz (1963)
Bisulfite pH4.0	Spruce	"	85.5%: M50%, S50%	Iwamida (1975)
	Balsam fir	Surface	Yield 81-94%: M	Horn (1968)
Neutral sulfite pH7.0	Spruce	"	79.0%: M98%, S2%	Iwamida (1975)
	Spruce	Cross section	Yield 84.5-88.0%: M-S ₁ , S ₁ -S ₂	Stockman (1957)
	"	"	78.4%: M-S ₁	"
	Birch	"	68.3%: M-S ₁	"
Mono-sulfite pH9.8	Spruce	Surface	79.0%: M96%, S4%	Iwamida (1975)
	"	"	Yield 88.2%: M92%, S8%	Iwamida (1975)
Na ₂ SO ₃ + CH ₂ O	"	"	91.6%: M/S=3-4/1	Nakano (1970)
	Spruce	Surface	Yield 87.7%: M/S=8-9/1	

M: middle layer, P: primary wall, S: secondary wall, S₁: outer layer of secondary wall
S₂: middle layer of secondary wall

Although the ratio of exposed secondary wall does not affect the sheet strength directly, flexibility of pulp fiber is a most important factor of sheet strength Table 11. Moreover, film-like substance formed from the middle lamella, outer layer substances from fiber and ray cells have high swelling properties and contribute to sheet strength at the stage of sheet formation as crosslinking substances. To digress for a moment, it is interesting to note that the film like substance formed from the middle lamella contains 60-70% lignin (24) and that its isolation has given valuable information to wood chemistry.

A few researchers believe that there may be some carbohydrates which play a role in inter-fiber bonding (25, 26). However, this is not a general assumption and its chemical structure is unknown. If it indeed exists, it possibly is a pectic substance. A paper by

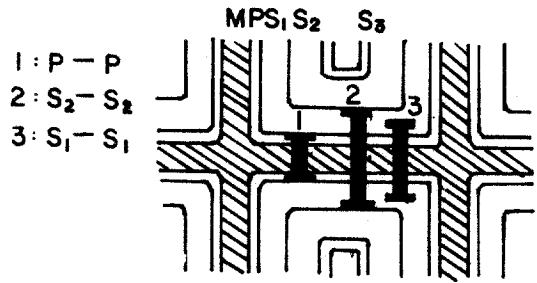


Fig. 7. Inter-fiber bonding by polysaccharide.

Kibblewhite (27) may provide a positive evidence of this substance indirectly. Radiata pine chips delignified with sodium chlorite were not fiberized, even though lignin contents were reduced to 0.12%. However, partially delignified chips reduced to 4.8-6.7%

Table 11. Ratio of secondary wall exposed on secondary wall and sheet strength

Pulp	Ratio of S on fiber	Breaking length, km (CSF 350)	Tear factor (CSF 600)	Zero-span, km (CSF 350)
T-8.6-94.0	80 (310)	4.4	90	8.9
T-8.6-85.7	60 (390)	6.9	107	9.8
T-8.6-73.2	70 (440)	9.1	108	9.9
T-4.0-94.0	—	4.5	87	8.7
T-4.0-86.3	50 (370)	7.0	102	9.0
T-4.0-75.3	—	9.6	94	10.1
T-1.8-85.2	100 (315)	5.2	92	8.6
K-8.6-91.8	70 (385)	3.3	35	8.3
K-8.6-85.8	70 (370)	8.1	87	9.9
K-8.6-77.9	60 (310)	10.2	95	10.3
K-4.0-91.7	30 (380)	1.6	—	6.2
K-4.0-84.5	80 (340)	6.4	71	9.6
K-4.0-79.2	70 (345)	8.1	95	10.0
K-1.8-86.7	90 (320)	4.5	50	9.6
K-UKP	70 (310)	13.7	109	12.5

T: fir, K: birch, T-8.6-94.0: fir pulp cooked with sulfite liquor of pH8.6 and cooked yield 94.0%,

S: secondary wall, Data in bracket: CSF ml of pulp used at electron microscopic study
his table that energy yield can be

lignin were fiberized, when the chips were post-treated with dilute alkali. This result may be consistent with Sumi's result (17), in which he found that high yield sulfite pulp contained no fiber bundles after dilute alkaline refining.

Fig. 7 shows a hypothetical picture of the inter-fiber bonding above-mentioned. Assuming the presence of such carbohydrate, it is very interesting to determine whether or not these carbohydrates affect the amounts of fiber bundles and the sheet strength.

5. Summary

Fig. 8 summarizes the present status of high yield pulp production and the directions of research on modification. A thick line indicates pulping process

presently in use. As mentioned previously, one kind of modification is to introduce hydrophilic groups onto the pulp. Still unsolved is whether or not the introduction of hydrophilic groups should be restricted to lignin only. Goring (28) reported that middle lamella lignin has fewer phenolic hydroxyl groups than cell wall lignin and suggested that such a difference in the lignin may be useful in the removal of middle lamella lignin.

The introduction of hydrophilic groups onto pulp may not be enough to modify high yield pulp. The removal of some portion of carbohydrate may be also necessary from the standpoint of softening of pulp fibers. There is no information at what lignin and carbohydrate, and how much should be removed. The combination with synthetic high polymers may

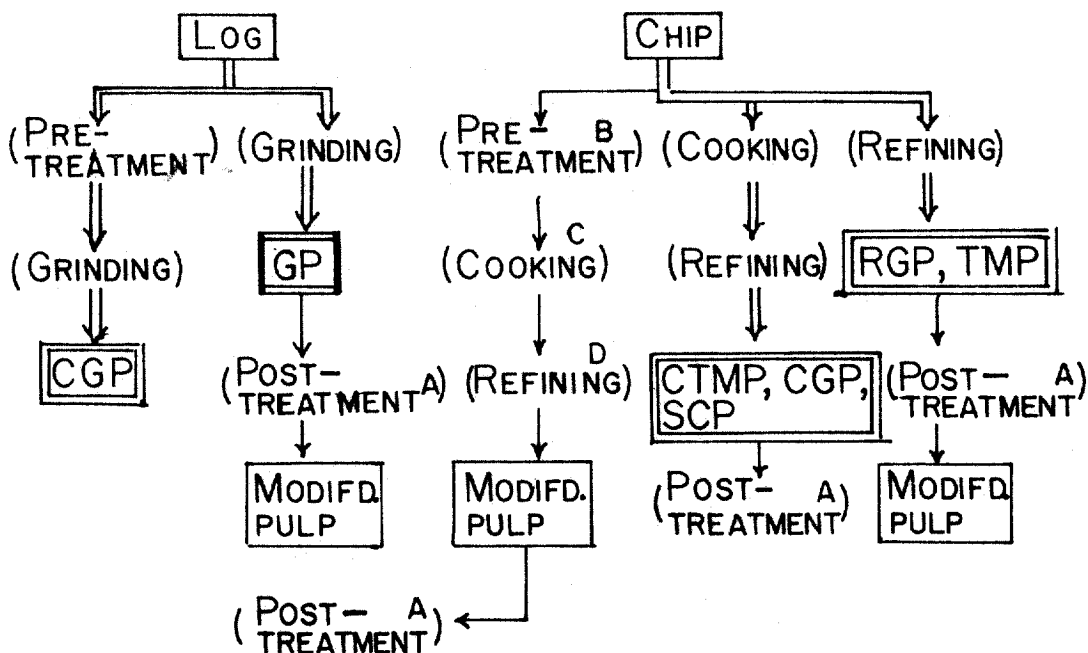


Fig. 8. High yield pulping processes.

- A: Solvent extraction, polymer coating, grafting, γ -ray irradiation, treatment with various chemicals
- B: Introduction of hydrophilic group
- C: Masonite process
- D: Refining in aq. alkali

also be important in modifying high yield pulp.

Prof. C. Schuerch of the State University of New York who was a visiting professor at the University of Tokyo in 1974, mentioned that the hydrophilicity of lignin would be promoted, if phenolic hydroxyl or carboxyl groups could be introduced into the aromatic nucleus of lignin. If this were possible, this process would also mean a pulp yield of more than 100%. This idea is just one example of the expectation made possible through lignin chemistry. Instead of the introduction of hydrophilic group, the oxidative degradation of aromatic nucleus of lignin

in may also be useful in promoting the hydrophilicity of pulp. In this case, ozone may be an excellent chemical. However, there are a lot of problems to be solved such as homogeneity of reaction and selectivity of ozone for lignin. The above ideas are summarized in Fig. 9.

There are many problems to be solved in the production of an excellent high yield pulp which is comparable to chemical pulp. The information from wood chemistry hopefully will elucidate some of the problems mentioned above.

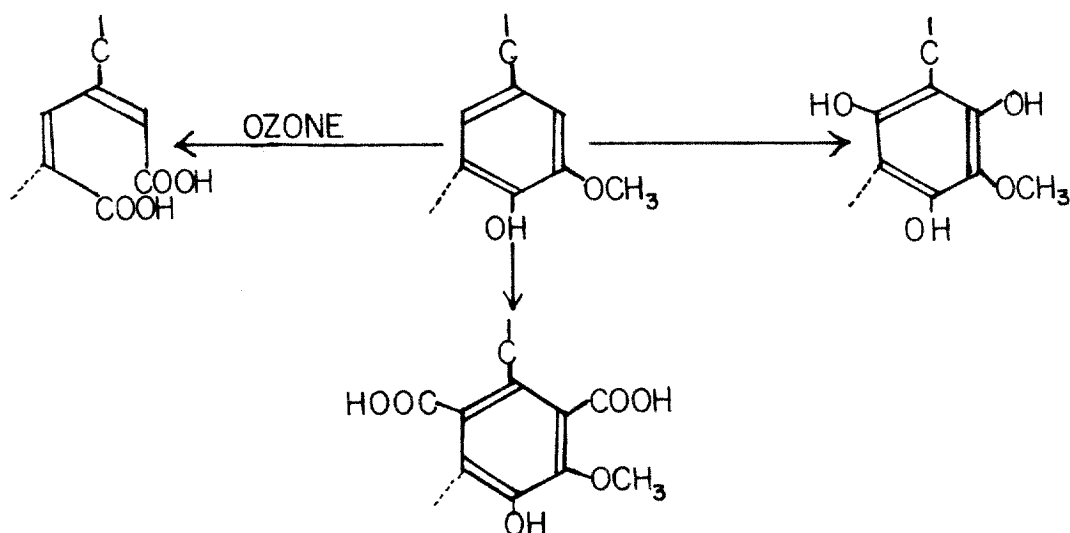


Fig. 9. Introduction of hydrophilic group onto lignin.

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