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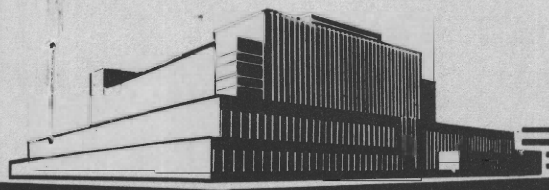

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

CONTINUOUS COLD SODA PULPING OF WEST COAST RED ALDER, TANOAK, MADRONE, AND BIGLEAF MAPLE

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Abstract

Red alder (Alnus rubra), tanoak(Pasania densiflora), madrone (Arbutus menziesii), and bigleaf maple (Acer macrophyllum) were pulped by the continuous cold soda semichemical method under various conditions of temperature and chemical concentration. A batch of cold soda pulp was also prepared from red alder for comparison. Pulps made by both the batch and continuous methods were used in the production of corrugating board.

The results of these experiments revealed the following:

Though increasing the concentration of the caustic soda in a range of 10.2 to 58.5 grams per liter increased the strength of the continuously made red alder pulps and lowered the fiberizing energy, it also increased the chemical consumption and decreased the brightness. Raising the temperature from 49° to 57° C., increased the strength of the continuously made red alder pulp, but also decreased the brightness. The treating temperature had no appreciable effect on the amount of chemical or fiberizing energy consumed.

Increasing the caustic soda concentration from 25.1 to 58.8 grams per liter, increased the strength and brightness of the continuously made tanoak pulps, but also increased the chemical consumption. The same effects were also noted when the temperature was raised from 30° to 43° C.

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Bigleaf maple was easier to pulp and produced a much stronger pulp than madrone. The maple wood, however, used twice as much chemical when both woods were treated with a caustic soda solution having a concentration of 28.4 grams per liter and a temperature of 40° C. When the woods were treated at 55° C. with a caustic soda solution having a concentration of 52 grams per liter, the amount of chemical consumed was the same for both, but the bigleaf maple pulp was still much stronger than the madrone pulp.

Corrugating boards made from red alder, tanoak, and bigleaf maple cold soda pulps exhibited very good ring compression and Concora values. Bigleaf maple pulp produced the best board, which had an average ring compression value of 56.9 pounds and a Concora value of 92.9 pounds. The madrone cold soda pulp proved unsatisfactory for producing corrugating board.

Introduction

Sizable quantities of red alder, tanoak, bigleaf maple, and madrone pulpwood are available to the pulp mills of the Pacific Northwest. Although some of these woods are now used to a limited extent for pulping, considerable interest has been shown recently in expanding their use for this purpose.

The batch cold soda semichemical process has been demonstrated experimentally to be especially suitable for making high-yield pulp from red alder, which could be used in the production of corrugating board and printing papers.[2] This investigation was made to determine the applicability of a continuous cold soda process in pulping these woods for use in corrugating board production.

Experimental Part

Chip Preparation

Freshly cut red alder, tanoak, bigleaf maple, and madrone logs grown in the Pacific Northwest region were obtained in the peeled condition.

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[2] Brown, K. J., and McGovern, J. N. "High-Yield Cold Soda Pulps and Products from Several Woods." Paper Industry, 35 (No. 1) 66-69 (April 1953).

The logs were separated according to species and converted into chips having an average dimension of 5/8 inch in the fiber direction. Before pulping, the oversized and undersized material was removed by passing the chips over a shaker screen. The portion that passed through a 1-1/4-inch screen and was retained on a 1/4-inch screen was accepted as satisfactory for pulping. The average moisture content and specific gravity of these woods are given in table 1.

Pulping

General. --Each of the four species was treated in a continuously operating roll-type refining mill.[3] During passage through this machine, the chips were compressed repeatedly between the inner surface of a revolving cylinder and a roll revolving within the cylinder, in the presence of a caustic soda solution for about 30 seconds before being discharged in the form of a partially fiberized pulp. The treated material from the roll mill was held for 1/2 hour before being pressed in a 3-section, 7-inch-diameter screw press to a dryness of about 50 percent.

A 36-inch-diameter, double-rotating disk mill with C-914 plates was used to refine (1) the press discharge material from the continuous production trials described above, and (2) a coarse red alder cold soda pulp that was made by roll milling chips treated batchwise with caustic soda in a digester.

The pulps made for corrugating board trial runs were screened through 0.012-inch slotted flat screens and washed on a wet machine before being converted into boards.

Red alder. --Preliminary continuous cold soda pulping trials were made on red alder using about 35 pounds (moisture-free weight) of chips at feed rates in a range of from 132 to 145 pounds per hour. The effect of caustic soda concentration was determined by running three trials (KM165, KM167, and KM168, table 2) at 50° C. using concentrations of 10.2, 26.0, and 58.5 grams per liter. To determine the effect of temperature, two trials (KM166 and KM167, table 2) were completed using a caustic soda concentration of 26.0 grams per liter at temperatures of 49° and 57° C.

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[3] Brown, K. J., and Hilton, R. D. "New-Fast-Continuous Cold Soda Hardwood Pulping Process." Paper Trade Journal, 140 (No. 21) 42-46, (May 21, 1956).

A quantity of pulp was prepared for use in corrugating board trial runs by treating about 85 pounds (moisture-free weight) of chips in the roll mill (KM182, table 2) at a temperature of 54° C. using a caustic soda concentration of 49.8 grams per liter and a feed rate of 114 pounds per hour.

For comparison with the continuous process, a quantity of pulp was also made batchwise (4240-KM183, table 2) for use in making a corrugating board trial run. About 100 pounds (moisture-free weight) of chips were treated in a 14-cubic-foot cylindrical digester for 1 hour at 150-pounds-per-square-inch-gage hydrostatic pressure, using a caustic soda solution with a concentration of 41.5 grams per liter and a temperature of 57° C. After draining the liquor, the treated chips were stored for 1 hour before they were refined to a coarse pulp in the roll mill. During this coarse refining, water was used instead of the caustic soda solution.

The press discharge material from the preliminary trials was also refined in the 36-inch-diameter disk mill. A sample of the resulting pulps was washed, dewatered, and submitted to strength development in a 1.5-pound test beater.

Tanoak. -- The effect of concentration in preparing cold soda pulp from tanoak was determined by making two trials (KM190 and KM193, table 2) at 30° C., using caustic soda solutions of 25.1 and 58.8 grams per liter. To determine the effect of temperature, two trials (KM190 and KM191, table 2) were run using a caustic soda concentration of 25.1 grams per liter at temperatures of 30° and 43° C. About 25 pounds (moisture-free weight) of chips at a feed rate of about 265 pounds per hour were used in these preliminary trials.

In each of these preliminary trials, a sample of the material discharged from the screw press was refined to a coarse pulp in an 8-inch-diameter, single-rotating disk mill. The resulting pulps were also washed, dewatered, and submitted to strength development in the test beater.

To make a quantity of pulp for use in a corrugating board trial run, about 135 pounds (moisture-free weight) of chips were treated in the roll mill (KM202, table 2) at a feed rate of 268 pounds per hour. A caustic soda solution having a concentration of 64.4 grams per liter and a temperature of 51° C. was used in the roll mill.

Bigleaf maple and madrone. --Continuous trials were made on bigleaf maple and madrone in an effort to prepare cold soda pulps of a quality suitable for use as a groundwood substitute. A caustic soda solution having a concentration of 28.4 grams per liter was used. The bigleaf maple trial (KM214, table 2) was run at a temperature of 38° C. using a feed rate of 198 pounds (moisture-free weight) per hour, while the madrone trial (KM213, table 2) was run at a temperature of 42° C. using a feed rate of 341 pounds per hour.

Continuous production trials were also conducted on these woods to obtain pulps suitable for use in corrugating board trial runs. The concentration of the caustic soda solution for these runs was 52.0 grams per liter. The bigleaf maple pulp (KM216, table 2) was prepared at a temperature of 53° C. using a feed rate of 197 pounds (moisture-free weight) per hour, while the trial made on the madrone (KM215, table 2) was run at 56° C. using a feed rate of 276 pounds per hour.

A sample of the material discharged from the screw press following each of these trials was refined to a coarse pulp in the 8-inch-diameter, single-rotating disk mill. The resulting pulps were washed, dewatered, and submitted to strength development in the test beater.

Boardmaking

Cold soda pulps produced continuously from red alder, tanoak, and bigleaf maple were converted into 26-pound corrugating boards on a 13-inch Fourdrinier paper machine. Each of these pulps was jordaned during the latter part of the run in order to increase the density of the board. It was necessary to make a 40-pound board from the madrone cold soda pulp in order to obtain a wet-web with enough strength to run it over the paper machine.

Discussion of Results

Pulping

Red alder. --The results of the preliminary continuous cold soda pulping trials given in tables 2 and 3 showed that an increase in the concentration of the caustic soda solution ranging from 10.2 to 58.5 grams per liter at 50° C. produced an increase in the amount of caustic soda used

from 3.5 to 14.7 percent (moisture-free wood basis), and increased the bursting strength and tearing resistance about 7 and 3 times, respectively. Coincidently, the fiberizing energy was decreased from 36.1 to 20.1 horsepower-days per air-dry ton, and the brightness reduced 2.5 percentage points. Raising the temperature from 49° to 57° C. at a constant caustic soda concentration of 26.0 grams per liter did not appreciably affect the energy requirements, although the bursting strength and tearing resistance did increase about 57 and 23 percent, respectively, while the brightness decreased 2.5 percentage points. During the continuous production run to produce a quantity of pulp for boardmaking trials, the amount of caustic soda used was 8.6 percent (treatment No. KM182), as compared to 12.0 percent for the batchwise digester treatment (treatment No. 4240-KM183). This does not, however, represent a true difference between the continuous and batchwise cold soda pulping processes, since the chips treated continuously were subsequently screw-pressed, which permitted the recovery of an amount of unused chemical. The chips treated batchwise in the digester were not screw-pressed.

Tanoak. --When the caustic soda concentration was increased from 25.1 to 58.8 grams per liter at a constant temperature of 30° C., the amount of caustic soda used increased from 4.8 to 10.2 percent, the bursting strength and tearing resistance was greater by about 11 and 3 times, respectively, and the brightness increased 2.3 percentage points. When a constant caustic soda concentration of 25.1 grams per liter was used, increases in the temperature from 30° to 43° C. caused the amount of caustic soda used to increase from 4.9 to 5.9 percent, the bursting strength and tearing resistance to increase about 4 and 1.8 times, respectively, and the brightness to increase 1.1 percentage points.

The energy used to fiberize the treated tanoak chips from the preliminary trials in the 8-inch disk mill are not given in this report, because of difficulty in obtaining accurate and reliable data.

Bigleaf maple and madrone. --Although both bigleaf maple and madrone were pulped continuously using a caustic soda concentration of 28.4 grams per liter at a temperature of about 40° C., the amount of chemical used and the strength properties of the resulting pulps were quite different. About twice as much caustic soda was used to make the bigleaf maple pulp, and its bursting strength and tearing resistance were about 5 and 2 times stronger, respectively, than that obtained from the madrone pulp. The difference in strength properties of the bigleaf maple and madrone pulps that were prepared at the higher concentration level and temperature (52.0 grams of caustic soda per

liter at about 55° C.) remained about the same as for the milder treatments, although the amount of caustic soda used was about 8.5 percent (moisture-free wood basis) for both woods.

To fiberize the treated bigleaf maple chips to a pulp having a freeness of 330 milliliters (Canadian Standard) for use in a corrugating board trial run, a total of 26.9 horsepower-days per ton of air-dry pulp was consumed, as compared with only 19.0 horsepower-days per ton of air-dry pulp needed to obtain a pulp at a freeness of 300 from madrone chips treated in the same manner.

Boardmaking

As shown in table 4, corrugating boards that had strength properties comparable to commercial boards were made from red alder, tanoak, and bigleaf maple pulps. Although the strength of the red alder pulp prepared batchwise was somewhat less than the continuously made pulp, it could be expected that the strength of the batch-made pulp would be increased to within the commercial range if the pulp were disk milled to a lower freeness. The jordaned bigleaf maple pulp produced the best board, which had an average ring crush value of 56.9 pounds and a Concora value of 92.9 pounds. This board was made at a headbox freeness of 350 milliliters (Canadian Standard).

The madrone cold soda pulp could not be made into a satisfactory board. It was necessary to raise the weight of the board to 40.4 pounds per 1,000 square feet in order to run this pulp over the paper machine. The average ring crush value of the board was good (62.5 pounds), but it lacked sufficient folding endurance to form a sample well in the Concora Medium Tester.

Table 1.--Average specific gravity and moisture content of red alder, tanoak, bigleaf maple, and madrone

Species	Average specific gravity (dry weight, green volume basis)	Average chip moisture content
		Percent
Red alder	0.478	38.9
Tanoak	.570	35.0
Bigleaf maple	.348	23.2
Madrone	.488	28.2

Table 2.--Conditions and results of cold soda treatments made on red alder, tanoak, bigleaf maple, and madrone

Treatment No.	Treating conditions: Temperature	Treating conditions: Sodium hydroxide concentration[1]	Treating conditions: Chip feed rate to roll mill (moisture-free basis)	Treating conditions: Liquor feed rate	Sodium hydroxide (moisture-free wood basis): Total used[2]	Sodium hydroxide (moisture-free wood basis): Recovered by screw pressing	Energy consumed (per ton of air-dry pulp) by--: Roll mill	Screw press	Disk mill[3]	Total	Pulp freeness (Canadian Standard)
	°C.	Gm. per liter	Lb. per hr.	Gal. per hr.	Percent	Percent	Hp.-days	Hp.-days	Hp.-days	Hp.-days	Ml.
RED ALDER											
KM165	50	58.5	145	51.8	18.7	4.0	5.3	4.2	10.6	20.1	530
KM166	57	26.0	136	58.1	9.9	1.7	5.2	3.9	13.2	22.3	480
KM167	49	26.0	134	57.9	10.0	1.5	6.7	2.3	15.0	24.0	360
KM168	48	10.2	132	49.5	3.5	0	7.0	4.4	24.7	36.1	375
KM182	54	49.8	114	46.3	17.5	8.9	2.3	2.7	16.1	21.1	375
[4]4240-KM183	57	41.5	115	.....	12.0	(5)	6.7	(5)	12.6	19.3	450
TANOAK											
KM190	30	25.1	259	52.6	4.9	.1	2.7	5.1	(6)	.....	.....
KM191	43	25.1	271	62.8	5.9	.1	1.5	5.2	(6)	.....	.....
KM193	30	58.8	260	61.2	13.4	3.2	1.2	4.1	(6)	.....	.....
KM202	51	64.4	268	73.8	14.9	3.4	2.8	2.0	15.5	20.3	310
BIGLEAF MAPLE											
KM214	38	28.4	198	72.9	9.8	2.7	5.5	.....	(6)	.....	.....
KM216	53	52.0	197	74.6	15.9	7.3	4.7	1.9	20.3	26.9	330
MADRONE											
KM213	42	28.4	341	63.2	5.2	.5	4.7	2.4	(6)	.....	.....
KM215	56	52.0	276	67.7	11.6	3.2	3.4	4.0	11.6	19.0	300

[1] Liquor analysis does not include the moisture in the chips.

[2] Includes all of the chemical consumed by reaction and left unconsumed in the treated chips (before screw pressing).

[3] Conducted in a 36-inch-diameter, double-rotating disk mill using C-914 plates unless otherwise noted.

[4] Chips were treated in a 14-cubic-foot digester for 1 hour at 150 p.s.i.g. and after being drained of excess liquor were stored for 1 hour prior to refining. A roll mill was used as a first-stage refiner with water instead of the caustic soda solution.

[5] Chips were not screw-pressed.

[6] Conducted in an 8-inch-diameter, single-rotating disk mill.

Table 3.--Physical properties of red alder, tanoak, bigleaf maple, and madrone cold soda pulps

Treatment No.	Brightness (G. E. equivalent)	Strength properties at a freeness of 350 milliliters (Canadian Standard)				
		Bursting strength	Tearing resistance	Breaking length	Folding endurance	Density
	Percent	Pts. per lb. per rm.[1]	Gm. per lb. per rm.[1]	Meters	Double folds	Gm. per cc.
RED ALDER						
KM165	36.0	0.23	0.54	2,750	2	0.50
KM166	33.7	.22	.54	2,650	1	.36
KM167	36.2	.14	.44	1,850	1	.40
KM168	38.5	.03	.18	560	0	.28
TANOAK						
KM190	33.2	.02	.20	130	0	.35
KM191	34.3	.08	.35	1,100	0	.37
KM193	35.5	.22	.57	3,150	2	.52
BIGLEAF MAPLE						
KM214	34.9	.14	.31	2,300	0	.46
KM216	38.2	.19	.38	2,350	0	.49
MADRONE						
KM213	31.1	.03	.15	700	0	.36
KM215	37.9	.05	.17	750	0	.40

[1] Ream of 500 sheets, 25 by 40 inches.

Table 4.--Physical properties of corrugating boards produced from red alder, tanoak, bigleaf maple, and madrone cold soda pulps

Treatment No.	Machine run No.	Headbox freeness (Canadian Standard)	Weight (per 1,000 square feet)	Thickness	Density	Bursting strength		Tearing resistance	Folding endurance	Tensile strength	Ring compression[1]		Concora[2]
						Mullen	Unit				In machine direction	Average	
		Ml.	Lb.	Mils	Gm. per cc.	Pts.	Pts. per lb. per ream.[3]	Gm. per lb. per rm.[3]	Double folds	Lb. per in. width	Lb.	Lb.	Lb.
RED ALDER													
KM182	5098	430	26.7	9.4	0.55	33.1	0.36	0.70	5	31.6	59.2	52.0	62.7
	[4]5099	310	27.2	9.3	.56	38.8	.41	.68	8	36.4	62.6	57.1	78.8
4240-KM183	5120	.....	26.0	9.3	.54	34.5	.39	.65	5	31.7	58.7	49.4	53.2
	[4]5121	460	25.9	9.1	.55	37.4	.42	.76	7	33.6	57.8	50.6	57.3
TANOAK													
KM202	5214	355	26.1	9.9	.51	34.1	.38	.79	4	32.7	66.7	54.6	67.7
	[4]5215	325	26.1	9.0	.56	34.3	.38	.77	4	33.2	66.9	54.9	75.5
BIGLEAF MAPLE													
KM216	5225	445	26.3	8.6	.59	46.0	.50	.68	10	38.0	67.9	58.9	77.1
	5226	350	26.4	8.0	.63	54.6	.60	.71	16	42.6	64.6	56.9	92.9
MADRONE													
KM215	5227	340	40.4	16.3	.48	16.8	.12	.34	0	24.3	73.1	62.5	(5)

[1]Test specimen of 1/2 by 6 inches.

[2]Test specimen of 10 A-flutes, 1/2 inch wide.

[3]Ream of 500 sheets, 25 by 40 inches.

[4]Pulp was jordaned.

[5]Samples did not form well in Concora Medium Tester.