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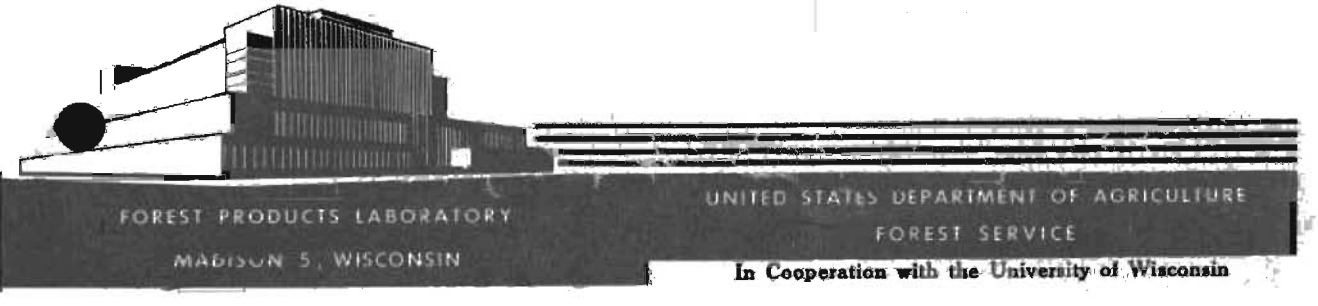

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

SULFATE PULPING OF BALSAM FIR

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Summary

Experiments were made on balsam fir wood to produce sulfate pulps with permanganate numbers ranging from 16.5 to 20.9 for bleachable grades and 28.6 for brown paper grades.

The pulps of lower permanganate numbers were bleached to a brightness of about 89 percent by a five-stage chlorine-chlorine dioxide bleaching process without significant change in strength. The brown paper grade pulp was stronger in bursting and tensile strengths and folding endurance than a comparable pulp made from southern pine, but was lower in tearing resistance in the freeness range of 300 to 500 milliliters (Canadian Standard). By beating the balsam fir pulp lightly to a freeness of approximately 675 milliliters, it would have strength properties about equal to those of southern pine kraft pulp at its optimum freeness.

Introduction

Balsam fir (Abies balsamea) has long been considered as an excellent northern softwood for use in sulfate pulping, but because of its low density, limited availability, and relatively high cost, it has not been used extensively for this purpose. The volume of balsam fir stands in the Northern Lake States is continually increasing, and the species is assuming potentially greater economic importance. Laboratory studies were therefore undertaken in order to obtain additional data on the sulfate pulping of this wood.

This report discusses experiments made to determine (1) the optimum pulping conditions necessary to produce balsam fir sulfate pulps with permanganate numbers ranging from 18 to 20 for bleachable grades and from 28 to 30 for

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

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brown paper grades, (2) the relationship of yield and strength properties of these pulps, and (3) the effect of bleaching on strength properties.

Description of the Wood

The balsam fir pulpwood (FPL shipment No. 4685) used in these experiments was freshly cut in the Minocqua, Wis., area and was received at the Laboratory with the bark on it. Sound logs, which had 1-inch disks cut from them for physical evaluation, were hand peeled and converted into 5/8-inch chips in a commercial-sized chipper. Before pulping, the oversized and undersized materials were removed by passing the chips over a gyrating screen equipped with 1-1/4- and 1/4-inch mesh screens. Physical tests on the wood showed the following average characteristics: (1) Diameter, 6.6 inches; (2) age, 29 years; and (3) specific gravity, 0.334 (dry weight, volume when green).

Pulping

The pulping digestions were made in an indirectly heated, stainless steel, tumbling digester of 0.8-cubic foot capacity. At the end of the cooking time at maximum temperature, the steam was shut off, the black liquor drained out, and the pressure relieved within about 5 minutes' elapsed time. The cooked chips were flushed out of the digester with hot (60° C.) water into an 80-mesh screen box. After draining, the cooked chips were disintegrated in a tank of hot water with an electric stirrer. The resulting pulps were returned to the screen box, washed with hot water until the effluent was clear, screened through a small, flat vibrating screen equipped with 12-cut plates, placed in canvas bags, and the water expressed in a hydraulic press to a consistency of about 30 percent. The pulp cake was shredded, weighed, and sampled for moisture content, yield determination, and permanganate numbers. The conditions and results of these digestions are shown in table 1.

As shown in table 1, two levels of active alkali, 16.0 and 17.5 percent (moisture-free wood basis), were used to produce the bleachable pulps with permanganate numbers of 20.9 and 20.0, respectively. The pulp from the 16 percent alkali level (total yield of 48.1 percent) had a time at cooking temperature of 2 hours, while the time for the pulp using the 17.5 percent alkali level (total yield of 47.7 percent) was 1-1/2 hours. Both pulps had screening rejects of 0.1 percent.

To produce the board grade pulp in the permanganate number range of 28 to 30, 15 percent active alkali was used. This pulp had a total yield of 49.5 percent, screening rejects of 0.4 percent, and a permanganate number of 28.6.

Other digestions were made using levels of active alkali of 15.6, 19.5, and 21.5 percent, which resulted in pulps having total yields of 48.7, 46.5, and 45.7 percent, screening rejects of 0.3, 0.1, and 0.1 percent, and permanganate numbers of 27.5, 16.5, and 15.9, respectively, as shown in table 1.

All of the pulping digestions were made at a sulfidity of 24.4 percent, using a 4 to 1 liquor-to-wood ratio.

Pulp Bleaching

Conditions for bleaching the balsam fir sulfate pulps to the desired brightness of about 88 percent were first established by small-scale tests using 50 grams of pulp. Then a larger quantity of each pulp was bleached to provide sufficient material for a beater-strength test evaluation. Three pulps, with permanganate numbers of 16.5, 20.0, and 20.9, were bleached by a five-stage procedure consisting of chlorination, caustic soda extraction, chlorine dioxide, caustic soda extraction, and chlorine dioxide.

The bleaching conditions and results of the bleaching tests are shown in table 2. The pulp of 16.5 permanganate number required 9.4 percent total chlorine equivalent to produce a brightness of 89.4 percent, that of 20.0 permanganate number required 10.1 percent for an 89.2 percent brightness, and that of 20.9 permanganate number required 10.63 percent to produce a brightness of 89.2 percent.

Testing

Selected unbleached and bleached pulps were evaluated for strength development in an experimental beater, and the handsheets were tested for physical properties.

TAPPI standard methods were followed for the analysis of the white and black liquors and for the determination of the permanganate numbers, freeness, and strength tests of the pulps. The handsheets, however, weighed approximately 72 instead of 60 grams per square meter and were pressed once instead of the two times required in TAPPI 205 m-58.

Results

In comparison to southern pine sulfate pulps of approximately the same permanganate number, the balsam fir pulp (board grade, permanganate number 28.6) had about 45 percent more bursting strength, 40 percent more tensile strength, twice as much folding endurance, and about 70 percent as much tearing resistance over a freeness range of 200 to 500 milliliters.

Since the bursting strength developed very rapidly upon beating, however, a balsam fir sulfate pulp could be obtained that had both bursting and tearing strengths about equal to those of southern pine by processing it lightly to a freeness of about 675 milliliters.

The bleachable grade of pulp made with 16.0 percent active alkali and 2 hours at cooking temperature appeared to have slightly better strength than one made using 17.5 percent active alkali with 1-1/2 hours at cooking temperature. After bleaching, however, these pulps were about equal in strength. Bleaching did not cause any significant change in the strength properties of the pulps.

Table 1.--Conditions and results of sulfate pulping of balsam fir

Digestion No.	Sulfate pulping[1]							Permanganate number
	Active alkali charged[2] (as Na_2O)	Black liquor				Yield[2]		
		Active alkali (as Na_2O)	Na_2S (as Na_2O)	NaOH (as Na_2O)	Specific gravity at 15° C.	Total	Screenings	
	Percent	G. per l.	G. per l.	G. per l.	°B.	Percent	Percent	
4054X	15.0	9.9	4.7	5.2	10.4	49.5	0.4	28.6
4047X	15.6	10.6	4.7	5.9	11.0	48.7	.3	27.5
[3]4056X	16.0	11.0	4.7	6.3	11.1	48.1	.1	20.9
4049X, 4050X, 4053X	17.5	14.2	5.8	8.4	11.7	47.7	.1	20.0
4048X	19.5	17.2	6.6	10.6	12.6	46.5	.1	16.5
4045X	21.5	21.2	7.4	13.8	13.4	45.7	.1	15.9

[1]Cooking conditions other than those shown above were 24.4 percent sulfidity, 4 to 1 liquor-to-wood ratio, 1.5 hours to 170° C., and 1.5 hours at 170° C.

[2]Moisture-free wood basis.

[3]Time at 170° C. was 2 hours.

Table 2.--Details of bleaching experiments on balsam fir sulfate pulp

Digestion No.	Permanganate number	Bleach No.	Stage No.	Bleaching data: Chemical	Amount applied	Amount consumed	Temperature	Consistence	Duration	pH: Initial	pH: Final	Brightness	Yield[1]
					Percent	Percent	°C.	Percent	Minutes			Percent	Percent
4048X	16.5	5047	1	Chlorine	6.50	6.20	25	3.0	90	2.2	2.0		
			2	Sodium hydroxide	2.00		70	10.0	60	11.9	11.7		
			3	Chlorine dioxide[2]	.91	.90	70	10.0	120	[3]6.0	4.0		
			4	Sodium hydroxide	1.00		60	10.0	60	11.9	11.8		
			5	Chlorine dioxide[2]	.19	.19	70	10.0	240	[3]6.0	3.8	89.1	
4048X	16.5	[4]5048	1	Chlorine	6.50	6.20	25	3.0	90	2.2	2.0		
			2	Sodium hydroxide	2.00		70	10.0	60	11.9	11.8		
			3	Chlorine dioxide[2]	.91	.90	70	10.0	120	[3]6.0	3.6		
			4	Sodium hydroxide	1.00		60	10.0	60	11.9	11.8		
			5	Chlorine dioxide[2]	.19	.19	70	10.0	120	[3]6.0	6.1	89.4	95.7
4049X	20.0	5059	1	Chlorine	6.60	6.50	25	3.0	60	1.9	1.8		
4050X			2	Sodium hydroxide	2.00		70	10.0	60	11.8	11.5		
4053X			3	Chlorine dioxide[2]	1.10	1.10	70	10.0	120	[3]6.0	2.9		
			4	Sodium hydroxide	1.00		60	10.0	60	11.9	11.4		
			5	Chlorine dioxide[2]	.23	.23	70	10.0	120	[3]6.0	3.5	88.3	
4049X	20.0	[4]5060	1	Chlorine	6.60	6.50	25	3.0	60	2.2	1.8		
4050X			2	Sodium hydroxide	2.00		70	10.0	60	11.9	11.5		
4053X			3	Chlorine dioxide[2]	1.10	1.10	70	10.0	120	[3]6.0	3.5		
			4	Sodium hydroxide	1.00		60	10.0	60	11.9	11.6		
			5	Chlorine dioxide[2]	.23	.23	70	10.0	140	[3]6.0	5.6	89.2	94.5
4056X	20.9	5061	1	Chlorine	6.90	6.80	25	3.0	60	1.6	1.5		
			2	Sodium hydroxide	2.00		70	10.0	60	11.8	11.4		
			3	Chlorine dioxide[2]	1.18	1.18	70	10.0	120	[3]6.0	3.1		
			4	Sodium hydroxide	1.00		60	10.0	60	11.9	11.6		
			5	Chlorine dioxide[2]	.24	.23	70	10.0	180	[3]6.1	5.6	87.8	
4056X	20.9	[4]5062	1	Chlorine	6.90	6.50	25	3.0	60	1.9	1.7		
			2	Sodium hydroxide	2.00		70	10.0	60	11.7	11.4		
			3	Chlorine dioxide[2]	1.18	1.18	70	10.0	120	[3]6.0	3.5		
			4	Sodium hydroxide	1.00		60	10.0	60	11.9	11.5		
			5	Chlorine dioxide[2]	.24	.24	70	10.0	240	[3]6.0	5.4	89.2	91.8

[1] On weight of unbleached pulp.

[2] Calculated as chlorine dioxide. (To convert to chlorine equivalent, multiply by 2.64.)

[3] Pulp and chlorine dioxide adjusted with acid before mixing to pH 6.0.

[4] Sufficient quantity bleached for beater strength evaluation.

Table 3.--Physical properties[1] of bleached and unbleached balsam fir sulfate pulps

Digestion No.	Permanganate number	Condition of pulp	Beating time	Freeness	Burst factor	Tear factor	Breaking length	Folding endurance (MIT)	Density
			Min.	Ml.			M.	Double folds	G. per cc.
4054X	28.6	Unbleached	12	675	95	186	11,200	1,100	0.53
			41	500	116	127	15,000	2,000	.73
			53	400	117	118	15,600	2,200	.76
			63	300	116	116	15,800	2,700	.77
4049X, 4050X, and 4053X	20.0	....do....	11	675	91	170	11,100	900	.57
			38	500	106	129	13,700	1,500	.72
			48	400	109	120	14,600	1,750	.75
			57	300	111	113	15,400	1,900	.76
		Bleached	8	675	99	212	12,000	950	.62
			30	500	104	128	13,800	1,950	.73
			40	400	106	121	14,700	2,300	.78
			50	300	108	115	15,600	2,550	.81
4056X	20.9	Unbleached	9	675	84	174	11,700	850	.56
			36	500	112	131	14,100	1,950	.68
			48	400	114	124	14,450	2,100	.72
			59	300	111	117	14,650	2,100	.75
		Bleached	5	675	80	222	7,600	600	.60
			30	500	104	136	14,900	1,900	.75
			41	400	104	121	15,400	2,100	.77
			50	300	102	115	15,650	2,300	.79
4048X	16.5	....do....	0	670	41	255	5,600	180	.48
			27	500	105	129	13,200	1,550	.71
			36	400	106	122	13,600	1,850	.74
			45	300	105	116	13,750	2,100	.77

[1] Tested according to TAPPI standard methods, except the handsheets weighed 72 instead of 60 grams per square meter and were pressed only once. The strength properties were interpolated at the stated freenesses.

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