SULFATE PULPING OF DEAD, STANDING JACK PINE

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SULFATE PULPING OF DEAD, STANDING JACK PINE (*Pinus banksiana*)

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Abstract

Sulfate-pulping characteristics and pulp properties were determined for a sample of jack pine cut in the dead, standing condition and were compared to those of two samples of green-cut jack pine obtained previously from a somewhat younger and faster-growing stand. The dead, standing wood gave kraft-type pulps essentially as strong as those from the green-cut wood, but in a little lower yield of pulp per unit of wood weight. Although the wood moisture of the dead wood was lower than that of the green-cut wood, a fact that would indicate a relatively low weight of chips charged to the digester and inefficient use of digester space, the drier, dead material had about the same moisture content as would be expected for green-cut wood stored for 1 year, as is common practice.

Introduction

In some of the overmature stands on the Superior National Forest, there is a large amount of dead but still standing jack pine wood that may amount in some places to 25 to 40 percent of the stand. This condition is the result of the spruce bud-worm infestation, suppression, and old age. The dead, standing trees left after the green trees have been removed are a menace and hindrance to men working the forest. Advantages cited for harvesting this dead wood are: (1) Haul and skid roads are already in place, (2) there are no branches to trim and no slash to dispose of, (3) cutting would be somewhat faster than for green wood, and (4) the dead material would be lighter to handle since the bark has largely dropped off.[2]

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

[2] Memorandum from H. B. Wales, January 16, 1947, Forest Service, Region 9, Milwaukee, Wis.

Experiments have been conducted at the Forest Products Laboratory to evaluate this material for sulfate pulping. About 1/2 cord of the dead, standing jack pine (shipment 2646) was supplied by the supervisor of the Superior National Forest. In this report the results obtained previously on the sulfate pulping of two samples of green-cut jack pine are used for comparison with the dead material. One of the green-cut samples was obtained from Itasca County, Minn. (shipment 1504),[3] and the other wood was from Pillager, Minn. (shipment 1300).[4]

Comparison of Dead, Standing to Green-cut Jack Pine Wood

The physical properties, growth characteristics, and chemical composition of the one sample of dead, standing and of the two samples of green-cut jack pine used in these experiments are given in tables 1 and 2. The dead material differed mostly from the others in having decay in about one-quarter of the wood (although only 2.4 percent of the wood was in an advanced stage of decay) and in having about half the moisture content of the freshly received, green-cut material.

The moisture content of wood is important in commercial operation because dry chips pack less densely in a digester than moist ones, so that less pulp will be obtained per digestion from the dry chips, with other factors being the same. The production may be reduced as much as 25 percent because of the dryness of the chips. The difference in the moisture content between dead- and green-cut wood may be much less after a year's storage of the two woods, however, since green wood dries considerably during storage.

The density of the dead material, as well as its solid volume per cord and its chemical composition, compared closely in these respects with one of the green-cut woods (shipment 1504). The dead, standing trees, however, were older, had slower growth, and contained more heartwood than the green-cut wood, but had about the same summerwood content. One of the shipments of green-cut wood (No. 1300) was fairly young, had had rapid growth, and had a slightly lower density than the others.

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[3] Chidester, Bray, and Curran. Growth Factors Influencing the Value of Jack Pine for Kraft and Sulfite Pulp. Paper Trade Journal, Vol. 109, No. 13, 36-42 (T.S. 170-176) (Sept. 28, 1939).

[4] Bray, Simmonds, and Mackin. The Experimental Production of Bond Papers from Southern Yellow and Northern Jack Pine Sulfate Pulps. Forest Products Laboratory Report, Project 7168-J60.

Sulfate-pulping Experiments

Sulfate Pulping of Dead, Standing Wood

The dead, standing wood was pulped under four sets of cooking conditions in which the ratio of chemical to wood varied. Three of the ratios, 17.5, 20.0, and 22.5 percent of total chemicals based on the moisture-free weight of the wood, gave kraft pulps, and the fourth, 27.5 percent of total chemicals used, gave a bleachable grade of sulfate pulp. The cooking data are given in table 3.

One effect of increasing the ratio of chemical to wood in pulping the dead material was to reduce the yield of screened kraft pulp from 45.1 to 43.2 percent by weight and from 11.3 to 10.8 pounds of pulp per cubic foot of solid wood. The screenings, based on the wood, dropped from 2.3 to 0.3 percent by weight. This reduction showed that the most complete pulping occurred with the highest chemical-wood ratio. The brightness of the kraft pulp after bleaching in a single-stage sodium hypochlorite process with 8.75 percent chlorine based on the pulp rose from 29.9 to 43.8 percent with this increase in the degree of pulping. The permanganate numbers decreased regularly with increase in chemical-wood ratio. The bleachable-grade pulp (digestion No. 1930-1931) was obtained in the lowest yield, 41.3 percent of the moisture-free wood and 10.4 pounds per cubic foot of solid wood. The screenings were 0.3 percent of the wood and the brightness of this pulp after the single-stage bleach was 55.1 percent.

The strengths of the pulps (table 5) were affected only slightly by the degree of pulping attained by the ratio of chemical to wood. The overall bursting and tensile strengths of the pulps decreased somewhat (about 10 and 16 percent, respectively) with increasing chemical-wood ratio. The tearing strengths and folding endurances of the pulps did not vary in any uniform way with chemical-wood ratio and yield.

Comparison of Results of Sulfate Pulping of Dead, Standing and of Green-cut Wood

The results from sulfate digestions of the two samples of green-cut wood with 20 percent total chemicals based on the wood are given in tables 3, 4, and 5. Because the wood had dried out prior to the pulping experiments, so that the moisture content of the chips used was in the same range as that of the chips from the dead, standing wood, moisture content is not a factor in this comparison.

In comparison with the green-cut wood pulped under closely the same conditions, the dead material (digestion Nos. 1922, 1928) gave a little lower yield on a weight basis, i.e., 44.6 percent compared to 47.2 percent. On the basis of yields of pulp per cubic foot of solid wood, however, the difference was not significant, with the figures being 11.1 and 12.0 pounds per cubic foot for the two green-cut woods and 11.2 pounds for the dead material. Screening rejects amounted to about 0.5 percent for the green and

1.0 percent for the dead wood (based on moisture-free wood), which are within the range found in commercial sulfate-cooking practice. Aside from the small reduction in pulp yield, the main disadvantage in pulping the dead wood would be caused by its greater dryness as compared to the pulping of freshly cut green wood which, as mentioned previously, would result in a decreased production per unit of digester space.

The brightness in a one-stage hypochlorite bleach test of the kraft pulp made from dead, standing wood was approximately 80 percent of that from green-cut material. The lower brightness was probably a result of the higher lignin content (5.4 compared to 4.4 percent) of the pulp from the dead material.

The chemical analysis of the pulps showed that the green-cut woods gave kraft pulps having somewhat higher pentosan and lower lignin contents than the dead wood.

The comparable pulp made from the dead wood (digestion Nos. 1922, 1928) was slightly higher in bursting strength than one pulp from green-cut wood, and slightly lower for the other. The tensile strength of the pulp from dead wood was about 90 percent of that of the pulp from one green-cut wood, but very nearly equal to that of the pulp from the other green-cut wood. The tearing strength of the pulp made from dead wood was 8 and 15 percent higher, respectively, than that of the pulps from the two green-cut woods.

Conclusions

On the basis of these data dead, standing jack pine may be used in place of the green-cut wood in the production of strong kraft pulps with no substantial change in over-all pulp strength, but with a little lower yield of pulp per unit weight of wood.

The drier condition of the dead jack pine as compared to that of unstored green-cut wood would cause a lower yield of pulp per unit of digester volume and a production rate as low as would be expected from green-cut wood that had been stored in a mill yard for about a year.

Table 1.--Physical and growth characteristics of pulpwood from dead, standing jack pine from the Superior National Forest, Minn., and from green-cut Minnesota jack pine

Condition when cut	Shipment No.		
	Dead-standing	Live	
	[1]2646	[2]1504	[3]1300
Weight of cord:			
Unbarked as received, pounds	2,878	.....	.....
Barked, moisture-free (solid volume x density), pounds	2,220	2,040	.....
Solid volume of wood per cord as received[4], cubic feet	88.4	80.5	.....
Number of 4-foot bolts per cord	140	61	.....
Loss in weight through peeling (basis unbarked disks, as received), percent	9.7	.....	.....
Loss in volume through peeling (basis unbarked cord, as received), percent	.....	9.4	.....
Density (basis disks, moisture-free weight per cubic foot, green volume), pounds	25.1	25.3	23.6
Moisture content of barked wood (basis disks as received), percent	24.9	47.9	29.3
Average diameter of peeled disks, inches	5.0	5.5	5.1
Volume of heartwood, percent	46.4	26.8	13.1
Volume of summerwood, percent	23.8	24.5	20.6
Volume of advanced decay, percent	2.4	None	None
Volume of incipient decay, percent	21.7	None	None
Age (average of disks), years	55.3	33.5	22.0
Rate of growth, average, rings per inch	22.0	12.2	8.7

[1]Wood from Superior National Forest, Minn.

[2]Wood from Itasca County, Minn.

[3]Wood from Pillager, Minn.

[4]Based on 128-cubic-foot cord of unbarked wood.

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Table 2.--Chemical analysis of pulpwood from dead, standing jack pine from the Superior National Forest, Minn., and from green-cut Minnesota jack pine

Description of material	Holocellulose	Alpha cellulose in holocellulose	Cross and Bevan cellulose	Alpha cellulose in Cross and Bevan cellulose	Lignin	Pentosans: Total	Pentosans: In cellulose	Solubility in: Alcohol-benzene	Solubility in: Ethyl ether	Solubility in: 1 percent sodium hydroxide	Solubility in: Hot water
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Dead, standing jack pine: Superior National Forest (Shipment No. 2646)	63.5	45.5	....	....	26.2	9.2	9.3	4.0	2.3	10.5	3.3
Green-cut jack pine 7-inch d.b.h. Itasca County, Minn. (Shipment No. 1504)	....	....	57.7	42.3	27.3	13.5	10.8	4.3	2.7	13.4	3.1
Green-cut jack pine from Pillager, Minn. (Shipment No. 1300)	....	....	58.3	42.3	27.5	14.3	10.7	2.5	1.5	12.1	2.6

Table 3.--Cooking,[1] yield, and bleach data on pulpwood from dead, standing and from green-cut jack pine

Digestion No.	Wood			Chemicals				Black liquor density at 15° C.	Yield of pulp (moisture-free) per 100 pounds of moisture-free wood		Bleach test data	
	Type	Shipment No.	Moisture content of chips	Charged: Concentration (initial): Calculated as Na_2O	Per 100 pounds of moisture-free wood: $NaOH + Na_2S$: As such	$NaOH + Na_2S$: As Na_2O	Volume	Sulfidity (based on active alkali)	Consumed		Screened	Screenings	Brightness: Pulp bleached with 8.75 percent chlorine	Permanganate No.
			Percent	Gm. per liter	Lb.	Lb.	Gal.	Percent	Percent	°B'.	Lb.	Lb.	Percent	
1921, 1927	Dead	2646	22.1	39.1	17.5	13.7	42	30.0	86.6	11.1	45.1	2.3	29.9	31.1
1922, 1928	Dead	2646	21.4	39.1	20.0	15.6	48	30.0	83.8	10.7	44.6	1.0	38.6	26.9
1923, 1929	Dead	2646	21.4	39.1	22.5	17.6	54	30.0	77.2	10.5	43.2	.3	43.8	22.8
1930, 1931	Dead	2646	22.3	46.9	27.5	21.5	55	30.0	69.1	11.6	41.3	.3	55.1	18.7
880, 904, 916	Green-cut	1504	29.4	39.1	20.0	15.6	48	33.9	85.1	10.8	47.3	.4	46.5	.....
823, 824 825	Green-cut	1300	17.4	39.1	20.0	15.6	48	33.9	83.8	10.9	47.1	.5	48.0	.....

[1] All digestions were made in 0.5-cubic-foot, steam-jacketed, rotary autoclaves heated indirectly with steam.

Weight of moisture-free wood charged---------4.0 pounds
Time to maximum temperature of 170° C.-------1.5 hours
Time at maximum temperature-----------------1.5 hours

Table 4.--Chemical analysis of jack pine sulfate pulps

Digestion No.	Wood		Chemical analysis of unbleached pulp			
	Condition when cut	Shipment No.	Holocellulose	Alphacellulose	Total pentosans	Lignin
			Percent	Percent	Percent	Percent
1921, 1927	Dead, standing	2646				
1922, 1928	do	2646	94.7	78.8	9.3	5.4
1923, 1929	do	2646				
1930, 1931	do	2646	96.1	81.1	7.1	3.6
880, 904, 916	Live	1504		[1]76.9	11.1	4.5
823, 824, 825	Live	1300		[1]78.7	10.9	4.3

[1]Determined on Cross and Bevan cellulose.

Table 5.--Physical properties of jack pine sulfate pulps

Digestion No.	Strength[1] at Canadian Standard freenesses interpolated from beater-test curves													
	Time of beating		Bursting strength (Mullen)		Tearing strength (Elmendorf)		Tensile strength: Breaking length		Tensile strength: Load		Folding endurance (M.I.T.)		Density	
	450 cc.	250 cc.	450 cc.	250 cc.	450 cc.	250 cc.	450 cc,	250 cc.	450 cc.	250 cc.	450 cc.	250 cc.	450 cc.	250 cc.
							Meters	Meters	Lb. per sq. in.	Lb. per sq. in.	Double folds	Double folds	Gm. per cc.	Gm. per cc.
1921, 1927	59	85	1.51	1.64	1.75	1.51	9,000	10,300	9,300	11,650	1,800	2,100	0.73	0.79
1922, 1928	52	79	1.42	1.54	1.86	1.57	8,500	9,250	8,700	10,500	1,300	1,650	.73	.80
1923, 1929	48	78	1.37	1.52	1.87	1.62	8,200	8,500	8,300	9,500	2,350	2,600	.73	.80
1930, 1931	47	75	1.36	1.44	1.78	1.59	7,700	8,600	8,200	10,100	1,350	2,350	.74	.81
880, 904, 916	....	....	1.37	1.39	1.72	1.47	.....	.....	8,800	10,400	.....	.....	.75	.80
823, 824, 825	56	75	1.53	1.60	1.57	1.40	.....	.....	9,900	11,800	.....	.....	.72	.77

[1]Test sheets conditioned and tested at 23° C. and 50 percent relative humidity; ream weight of 55 pounds; ream size of 500 sheets, each 25 x 40 inches.