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9. ABSTRACT

Identifies wood chipping, air classification, and silica problems that need to be considered in the design of facilities for the processing of mixed tropical hardwoods. All of the tropical hardwood logs used in this project had the back removed prior to chipping. The chips were screened to remove the over- and undersized materials. Table 1 shows the amounts of oversize and fines obtained from each species. With both the Philippine and the Colombian species, the largest amounts of total rejects were found with the highest density woods. Those rejects were mostly in the form of fines. The most difficult species to chip was the Colombian wood "Caimo," which had a specific gravity of 0.859 and gave about 55% rejects. Air classification proved impossible with chips made from freshly harvested wood because the wet weight, wet volume specific gravity of all the woods fell into a very narrow range. Some of the lightest woods contain enough moisture to make them as heavy as the truly denser woods when freshly cut. With drying, the efficiency of air classification could be increased considerably. In the kraft pulping of these woods, most of the silica will be dissolved into the cooking liquor. Regardless of the original amount of silica in the wood, the levels of silica in the black liquors appeared to reach maximums after only two to three cycles. With 1.5 silica in the black liquors, severe problems, such as reducing evaporator capacity by forming a scale of sodium silicate or other insoluble silicate compounds on the evaporator tubes, could occur. With an accumulation of silica in the causticizer, the sedimentation rate of lime sludge is greatly reduced. These problems need to be considered in designing a kraft pulpmill for utilizing tropical hardwoods containing silica.

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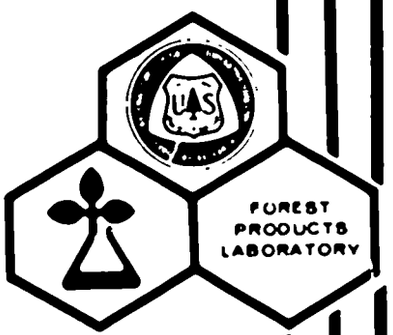
SOME POTENTIAL PROCESSING PROBLEMS WITH MIXED TROPICAL HARDWOODS

By

JAMES F. LAUNDRIE, Chemical Engineer



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In Cooperation with the University of Wisconsin

SOME POTENTIAL PROCESSING PROBLEMS WITH MIXED TROPICAL HARDWOODS

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Summary

Some wood chipping, air classification, and silica problems are identified and need to be considered in the design of facilties for the processing of mixed tropical hardwoods.

Chipping

All of the tropical hardwood logs used in this project had the bark removed prior to chipping in a 47-inch-diameter, four-knife, Carthage chipper. The chips were screened to remove the over- and undersized materials using a gyrating screen having 1-1/4- and 1/4-inch square-holed screens. Shown in table 1 are the amounts of oversize and fines obtained from each species. Unfortunately, with the Philippine species, the reject materials were combined prior to weighing and the relative amounts of each are unknown. However, with the Colombian and the Ghanaian species the oversize and fines were weighed separately. With both the Philippine and the Colombian species, the largest amounts of total

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

rejects were found with the highest density woods. This is contrary to the results found with the Ghanaian species where woods in the same high density range produced very few rejects. Some of the lowest density woods also produced large amounts of rejects, but these were mostly of oversize materials which could be rechipped. Wherever there were larger amounts of rejects from the higher density woods, those rejects were mostly in the form of fines. This is also evident from the results of screen classifying the accepted chips as shown in table 2. The most difficult species to chip was the Colombian wood "Caimo," which had a specific gravity of 0.859 and gave about 55 percent rejects. The main problem with this species was that the chipper knives became dull very rapidly even though this species contained only 0.55 percent silica. With the Philippine species "Antipolo," which contained 4.55 percent silica and had a specific gravity of 0.469, no chipper knife dulling problems occurred.

Other types of chippers and knives were not evaluated because that was beyond the scope of this project. However, these results do indicate potential chipping problems from a variety of causes including wood structure, the amount of silica, wood specific gravity, chipper and knife design, and knife metallurgy.

Air Classification

A major premise of this project was that the higher specific gravity species could be separated from the mixtures to provide fuel with an expected improvement in quality of the pulp produced from the remaining

chips. The feasibility of doing this via air classification was demonstrated and reported in AID Report No. 1, "Exploratory Kraft and NSSC Pulping of Mixtures of 50 Philippine Hardwoods," and in AID Report No. 7, "Ghanaian Hardwood Mixtures for Pulp and Paper." However, air classification was successful only because both the Philippine and the Ghanaian woods lost some moisture between harvesting and the time when they were converted into chips at the Forest Products Laboratory. Shown in table 3 is the variation of wood specific gravity with moisture content of the Philippine woods. From these data it is evident that it would have been impossible to air classify chips made from freshly harvested wood because the wet weight, wet volume specific gravity of all the woods fell into a very narrow range. Some of the lightest woods, on the basis of dry weight, wet volume when freshly cut, contain enough moisture to make them as heavy as the truly denser woods.

The 80 percent efficiency obtained in air classifying the partially dried chips was surprisingly high considering again the wet weight, wet volume of these woods. With further drying, this efficiency could, no doubt, be increased considerably.

Should air classification of chips be necessary to provide either fuel or improved pulp quality, then consideration must be given to determining the best method of drying the wood. Because of the high humidity and frequency of rainfall in most of the tropical forests being considered for implementation of these findings, drying of the chips, with perhaps waste heat in the flue gasses, would appear to be the most reasonable approach.

Silica

The problem of silica in the wood as it affects the chipping operation has already been mentioned. However, in the kraft pulping of these woods, most of the silica will be dissolved into the cooking liquor. Shown in table 4 are the effects of black liquor recycling on the distribution of silica. Four cycles were made on woods with three levels of silica--0.3, 1.0, and 4.6 percent. In each of these cycles one-half of the total water to wood ratio was undiluted black liquor from the previous digestion. Recycling of the black liquor did not increase the amount of silica remaining with the pulps. While the pulps made from the wood containing 0.3 percent silica had about 0.08 percent silica, the amount of silica in the pulps made from the wood containing 1.0 percent silica increased to about 0.3 percent. Unexpectedly, the pulps made from the wood with 4.6 percent silica also contained about 0.3 percent silica.

Regardless of the original amount in the wood, the levels of silica in the black liquors appeared to reach maximums after only two to three cycles. These maximums, however, increased with increasing amounts of silica in the wood reaching 0.08, 0.14, and 1.5 percent, respectively.

With 1.5 percent silica in the black liquors, severe problems, such as reducing evaporator capacity by forming a scale of sodium silicate or other insoluble silicate compounds on the evaporator tubes, could occur. In the recovery furnace silicate compounds are known to gradually form a beehive-like deposit on the walls and between boiler tubes. When there is an accumulation of silica in the causticizer, the sedimentation rate of lime sludge is greatly reduced. These problems need to be considered

in designing a kraft pulpmill for utilizing tropical hardwoods containing silica.

Table 1.--Chipping rejects from various tropical hardwoods

No.	Species		Specific gravity (dry weight, green volume)	Chipping rejects		
	Common name	Botanical name		Total	Oversize (+1-1/4 in.)	Fines (-1/4 in.)
				Pct	Pct	Pct
		PHILIPPINE SPECIES				
1	Tangisang-bayauak	Ficus variegata	0.236	6.1	--	--
2	Binuang	Octomeles sumatrana	.242	7.6	--	--
3	Kapok	Ceiba pentandra	.244	13.2	--	--
4	Balilang-uak	Meliosma macrophylla	.260	6.7	--	--
5	Rarang	Erythrina subumbrans	.264	11.4	--	--
6	Kaitana	Zanthoxylum rhetsa	.296	4.4	--	--
7	Ilang-ilang	Cananga odorata	.308	8.2	--	--
8	Gubas	Endospermum pletatum	.316	4.0	--	--
9	Dita	Alstonia scholaris	.316	--	--	--
10	Anabiong	Trema orientalis	.319	12.6	--	--
11	Hamindang	Macaranga bicolor	.324	5.2	--	--
12	Balanti	Homalanthus populneus	.356	7.6	--	--
13	Mayapis	Shorea squamata	.366	4.1	--	--
14	Matang-arau	Melicope triphylla	.381	6.7	--	--
15	Malasantol	Sandoricum vidalii	.394	8.3	--	--
16	White lauan	Pentacme contorta	.401	4.8	--	--
17	Tulo	Alphitonia philippinensis	.422	12.6	--	--
18	Tangile	Shorea polysperma	.429	5.3	--	--
19	Pahutan	Mangifera altissima	.435	4.8	--	--
20	Apanit	Mastixia philippinensis	.447	5.6	--	--

Table 1.--Chipping rejects from various tropical hardwoods--continued

No.	Species		Specific gravity (dry weight, green volume)	Chipping rejects		
	Common name	Botanical name		Total	Oversize (+1-1/4 in.)	Fines (-1/4 in.)
				Pct	Pct	Pct
		PHILIPPINE SPECIES--continued				
21	Lago	Pygeum vulgare	0.451	16.9	--	--
22	Antipolo	Antocarpus blancoi	.469	16.1	--	--
23	Bagtikan	Parashorea plicata	.478	9.5	--	--
24	Sakat	Terminalia nitens	.485	8.4	--	--
25	Red lauan	Shorea negrosensis	.510	3.7	--	--
26	Itangan	Weinmannia luzoniensis	.526	4.3	--	--
27	Piling-liitan	Canarium luzonicum	.549	5.8	--	--
28	Palosapis	Anisoptera thurifera	.554	3.4	--	--
29	Lomarau	Swintonia foxworthyi	.559	4.7	--	--
30	Malabetis	Madhuca oblongifolia	.560	3.1	--	--
31	Dangkalan	Calophyllum obliquinervium	.568	5.1	--	--
32	Panau	Dipterocarpus gracilis	.576	3.3	--	--
33	Katmon	Dillenia philippinensis	.592	9.0	--	--
34	Batitinan	Lagerstroemia piriformis	.597	3.1	--	--
35	Katong-lakihan	Amoora macrophylla	.608	5.5	--	--
36	Narig	Vatica mangachapoi	.618	2.5	--	--
37	Miau	Dysoxylum euphlebium	.623	3.5	--	--
38	Apitong	Dipterocarpus grandiflorus	.623	2.8	--	--
39	Bok-bok	Xanthophyllum excelsum	.639	3.3	--	--
40	Kamatog	Erythrophloeum densiflorum	.650	6.6	--	--

Table 1.--Chipping rejects from various tropical hardwoods--continued

No.	Species		Specific gravity (dry weight, green volume)	Chipping rejects		
	Common name	Botanical name		Total	Oversize (+1-1/4 in.)	Fines (-1/4 in.)
				Pct	Pct	Pct
		PHILIPPINE SPECIES--continued				
41	Dalingdingan	Hopea foxworthyi	0.667	3.0	--	--
42	Katilma	Diospyros nitida	.679	7.1	--	--
43	Yakal	Shorea astylosa	.718	3.8	--	--
44	Kamagong	Diospyros philippinensis	.720	6.0	--	--
45	Katong-matsin	Chisocheton pentandrus	.725	13.2	--	--
46	Manaring	Lithocarpus soleriana	.736	5.2	--	--
47	Ipil-ipil	Leucaena leucocephala	.737	10.9	--	--
48	Bolong-eta	Diospyros pilosanthera	.743	12.5	--	--
49	Makaasim	Syzygium nitidum	.778	9.8	--	--
50	Alupag-amo	Litchi philippinensis	.793	23.3	--	--
		GHANAIAN SPECIES				
1	Otu	Cleistopholis patens	.241	4.8	1.2	3.6
2	Effeu	Hannoa kleineana	.283	6.0	5.1	.9
3	African corkwood	Musanga cecropioides	.301	10.4	9.1	1.3
4	Obeche	Triplochiton scleroxylon	.302	5.6	4.4	1.2
5	Antiaris	Antiaris africana	.312	12.7	11.1	1.6
6	Canarium	Canarium schweinfurthii	.337	2.3	1.4	.9
7	Akoret	Discoglypremna caloneura	.370	2.6	1.3	1.3
8	African mahogany	Khaya ivorensis	.413	8.4	7.8	.6
9	Dahoma	Piptadeniastrum africanum	.442	2.1	.6	1.5
10	Gedu nohor	Entandrophragma angolense	.450	28.2	.5	27.7

Table 1.--Chipping rejects from various tropical hardwoods--continued

No.	Species		Specific gravity (dry weight, green volume)	Chipping rejects		
	Common name	Botanical name		Total	Oversize (+1-1/4 in.)	Fines (-1/4 in.)
				Pct	Pct	Pct
		GHANAIAN SPECIES--continued				
11	Niangon	Tarrietia utilis	0.460	11.0	10.3	0.7
12	Scented guarea	Guarea cedrata	.485	1.6	.3	1.3
13	Makore	Tieghemella heckelii	.499	2.4	1.0	1.4
14	Tallow tree	Allanblackia floribunda	.540	8.2	1.6	6.6
15	Lokonfi	Celtis adolphi-friderici	.549	4.8	4.0	.8
16	Brown sterculia	Sterculia rhinopetala	.552	3.1	1.9	1.1
17	Eyong	Sterculia oblonga	.589	2.6	1.1	1.5
18	Adjouba	Dacryodes klaineana	.692	2.0	.2	1.8
19	Afina	Strombosia glaucescens	.697	2.6	.6	2.0
20	Kane	Anogeissus leiocarpus	.708	2.2	1.1	1.1
21	Kokoti	Anaopyxis kleineana	.721	3.2	.8	2.4
22	Ekki	Lophira alata	.808	4.4	.9	3.5
		COLOMBIAN SPECIES				
1	Peine mono	Apeiba apera	.141	10.4	5.0	5.4
2	Ceiba	Ceiba pentandre	.225	9.3	3.9	5.4
3	Yarumo	Cecropia sp.	.250	16.6	13.3	3.3
4	Cirpo	Pourouma sp.	.369	5.9	3.8	2.1
5	Chingale	Jacaranda copaia	.372	5.5	4.2	1.3

Table 1.--Chipping rejects from various tropical hardwoods--continued

No.	Species		Specific gravity (dry weight, green volume)	Chipping rejects		
	Common name	Botanical name		Total	Oversize (+1-1/4 in.)	Fines (-1/4 in.)
				Pct	Pct	Pct
		COLOMBIAN SPECIES--continued				
6	Dormilon	Vochysia ferruginea	0.447	3.6	1.6	2.0
7	Sande	Brosimum utile	.494	3.8	1.8	2.0
8	Sangretoro	Viroula sebifera	.511	4.9	1.9	3.0
9	Arenillo	Catostemma alstonii	.536	4.5	2.0	2.5
10	Canelo	Nectandra sp.	.546	3.6	1.4	2.2
11	Perillo negro	Couma macrocarpa	.547	4.9	1.1	3.8
12	Casaco	Hieronyma sp.	.603	6.2	1.4	4.8
13	Carbonero	Enterolobium schomburgkii	.634	4.5	1.4	3.1
14	Chocho	Ormosia paraensis	.671	6.7	2.1	4.6
15	Carreto	Aspidosperma sp.	.692	3.4	.9	2.5
16	Lecheperra	Helicostylis tomentosa	.785	4.4	1.1	3.3
17	Tamarindo	Dialium guianense	.823	15.0	5.5	9.5
18	Caimo	Pouteria sp.	.859	55.4	17.4	38.0

Table 2.--Classification of screened chips from Philippine hardwoods

Species[1/]	Specific gravity (dry weight, green volume)	Amounts					
		+1-1/8 inches	+7/8 inch	+5/8 inch	+3/8 inch	+3/16 inch	-3/16 inch
		Pct	Pct	Pct	Pct	Pct	Pct
1	0.236	6	24	31	30	8	1
2	.242	6	30	31	27	5	1
3	.244	9	29	31	25	5	1
4	.260	4	28	36	26	6	1
5	.264	10	47	26	15	2	1
6	.296	4	44	30	19	3	0
7	.308	5	25	37	25	6	1
8	.316	1	27	40	26	5	1
9	.316	8	42	30	17	3	1
10	.319	7	49	29	13	2	0
11	.324	3	24	37	29	7	1
12	.356	7	42	30	18	3	0
13	.366	2	25	37	30	6	1
14	.381	4	35	32	22	6	0
15	.394	5	39	31	20	4	0
16	.401	5	33	31	25	5	0
17	.422	10	51	26	11	2	0
18	.429	4	38	32	21	5	0
19	.435	2	26	34	29	9	1
20	.447	6	29	32	28	5	1

Table 2.--Classification of screened chips from Philippine hardwoods--continued

Species[1/]	Specific gravity (dry weight, green volume)	Amounts					
		+1-1/8 inches	+7/8 inch	+5/8 inch	+3/8 inch	+3/16 inch	-3/16 inch
		Pct	Pct	Pct	Pct	Pct	Pct
21	0.451	11	40	28	18	3	0
22	.469	7	32	32	24	6	1
23	.478	8	35	30	22	5	0
24	.485	5	30	31	26	7	1
25	.510	0	24	32	33	10	1
26	.526	7	36	33	20	4	0
27	.549	3	46	30	17	3	0
28	.554	1	23	34	33	8	1
29	.559	4	41	33	18	4	0
30	.560	2	30	37	25	5	1
31	.568	1	26	36	29	8	0
32	.576	2	25	34	31	8	1
33	.592	1	17	27	33	19	2
34	.597	2	30	38	24	5	1
35	.608	1	10	25	38	23	1
36	.618	2	21	37	33	7	0
37	.623	2	17	34	34	11	1
38	.623	1	25	36	30	8	1
39	.639	2	15	30	39	13	1
40	.650	3	18	29	35	13	1

Table 2.--Classification of screened chips from Philippine hardwoods--continued

Species[1/]	Specific gravity (dry weight, green volume)	Amounts					
		+1-1/8 inches	+7/8 inch	+5/8 inch	+3/8 inch	+3/16 inch	-3/16 inch
		Pct	Pct	Pct	Pct	Pct	Pct
41	0.667	1	22	36	32	8	0
42	.679	1	26	28	31	13	1
43	.718	1	15	31	37	15	1
44	.720	5	24	34	27	10	1
45	.725	6	24	29	31	10	1
46	.736	1	17	32	36	13	1
47	.737	10	28	30	24	8	1
48	.743	6	25	28	26	14	1
49	.778	2	13	25	38	21	2
50	.793	2	9	18	36	32	3

1/ See table 1 for common and botanical names of species.

Table 3.--Variation of specific gravity with moisture content of Philippine hardwoods

Species[1/]	Moisture content		Specific gravity		
	Fresh-cut (literature)	As received at FPL	Dry-weight, wet-volume	Wet-weight, wet-volume	
				Fresh-cut	As received
	Pct	Pct			
1	274	171	0.236	0.883	0.640
2	--	116	.242	--	.523
3	345	201	.244	1.086	.978
4	217	83	.260	.824	.476
5	341	154	.264	1.164	.671
6	173	83	.296	.808	.542
7	233	102	.308	1.026	.622
8	--	90	.316	--	.600
9	137	95	.316	.749	.616
10	237	95	.319	1.075	.622
11	191	79	.324	.943	.580
12	168	61	.356	.954	.573
13	124	67	.366	.820	.611
14	169	65	.381	1.025	.629
15	96	70	.394	.772	.670
16	110	81	.401	.842	.726
17	139	56	.422	1.009	.658
18	89	52	.429	.811	.652
19	--	80	.435	--	.783
20	116	91	.447	.965	.854
21	91	64	.451	.861	.740
22	--	96	.469	--	.919
23	102	50	.478	.966	.717
24	98	93	.485	.960	.936
25	103	55	.510	1.035	.790
26	132	74	.526	1.220	.915
27	99	45	.549	1.093	.796
28	--	68	.554	--	.931
29	87	61	.559	1.045	.900
30	124	67	.560	1.254	.935

Table 3.--Variation of specific gravity with moisture content of Philippine hardwoods--continued

Species[1/]	Moisture content		Specific gravity		
	Fresh-cut (literature)	As received at FPL	Dry-weight, wet-volume	Wet-weight, wet-volume	
				Fresh-cut	As received
	Pct	Pct			
31	79	75	0.568	1.017	0.994
32	80	73	.576	1.037	.996
33	--	59	.592	--	.941
34	121	74	.597	1.319	1.039
35	99	83	.608	1.210	1.113
36	--	45	.618	--	.896
37	76	60	.623	1.096	.997
38	83	70	.623	1.140	1.059
39	93	70	.639	1.233	1.086
40	--	65	.650	--	1.073
41	--	50	.667	--	1.000
42	67	49	.679	1.134	1.012
43	--	52	.718	--	1.091
44	--	47	.720	--	1.058
45	127	60	.725	1.646	1.160
46	81	52	.736	1.332	1.119
47	78	55	.737	1.312	1.142
48	--	43	.743	--	1.062
49	--	42	.778	--	1.105
50	--	45	.793	--	1.150

1/ See table 1 for common and botanical names of species.

Table 4.--Effect of kraft black liquor recycling on the distribution of silica

Cycle No.[1]	Black liquor				Pulp			
	Total solids[2]	Ash[2]	Silica[2]	Heating value	Total yield[3]	Kappa No.	Ash[4]	Silica[4]
	Pct	Pct	Pct	Btu/lb of solids	Pct		Pct	Pct
PHILIPPINE MIXTURE C--0.3 PERCENT SILICA								
1	14.7	6.2	0.05	--	47.2	23.1	1.1	0.08
2	--	--	--	--	46.3	21.0	1.3	.08
3	23.2	9.2	.07	--	47.4	22.4	1.3	.09
4	23.0	9.4	.08	6,562	47.3	22.4	1.4	.07
PHILIPPINE MIXTURE C ENRICHED WITH TWO HIGH-SILICA SPECIES--1.0 PERCENT SILICA								
1	14.7	6.2	.08	--	46.7	21.6	1.3	.30
2	19.9	8.2	.15	--	48.0	22.5	1.5	.32
3	21.9	9.0	.13	--	47.2	21.2	1.3	.29
4	22.9	9.4	.14	6,832	47.6	22.0	1.4	.31
PHILIPPINE WOOD--ANTIPOLO (ARTOCARPUS BLANCOI)--4.6 PERCENT SILICA								
1	15.0	6.7	1.1	--	48.4	31.6	1.4	.30
2	19.8	8.8	1.4	--	48.9	32.2	1.3	.29
3	22.0	9.3	1.3	--	48.7	28.9	1.2	.30
4	21.5	9.4	1.5	6,797	49.5	32.3	1.2	.26

1/ One-half of the 4 to 1 water to wood ratio was undiluted black liquor from the previous digestion.
2/ Based on weight of black liquor.
3/ Based on moisture-free weight of wood.
4/ Based on moisture-free weight of screened pulp.