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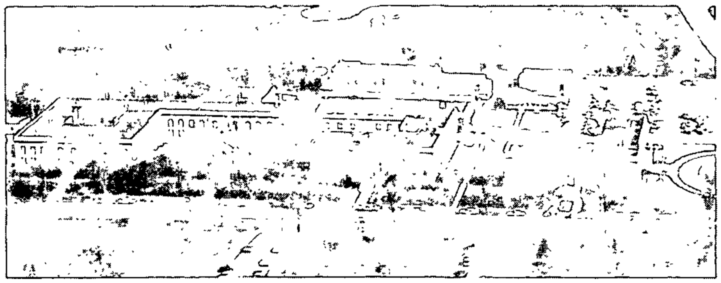

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KRAFT PULPING OF GREEN SLASH PINE STUMPS

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INTRODUCTION

A sample of green slash pine stumpwood from northern Florida was evaluated for its potential as a raw material in the manufacture of high yield kraft linerboard. The wood particles sample as received was indicative of the practical problems involved in utilizing this kind of wood waste; i.e., the conventional wood cleaning and chipping procedures used resulted in a great deal of oversize chips and substantial dirt contamination. Pulps made from the stumpwood after chip size reduction and dirt removal were higher in Kappa number (lignin content) and lower in yield than equivalent high yield kraft pulps made from pine stemwood. Because of a lower wood density, less of this material could be processed in a cooking vessel at a given time. The chemical demand was higher and there were more extractives in the stumpwood than would be expected in stemwood. The pulp color was relatively dark and the physical properties were lower than those obtained from reference pulps made from conventional pine chips. One exception was folding endurance, which was higher in the stumpwood pulp. It was concluded that the stump portion of slash pine pulpwood did not have the qualities which would make it the equivalent of an equal amount of stemwood in the production of high yield kraft pulp and that there was considerable probability of production problems related to field dirt contamination.

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Kraft pulping of green slash pine stumps

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The increasing need for full utilization of all of the nation's forest resources has resulted in changes in harvesting practices in many woods operations. Most of these changes have occurred as equipment manufacturers have developed and perfected mechanical devices which can be demonstrated to operate satisfactorily on a given terrain and at a savings in manpower. An example of this is the harvesting and chipping of whole trees.

The Fourdrinier Kraft Paperboard Institute (FKI) has reflected its members interest in better utilization of their tree stands by sponsoring investigations in the area of whole tree pulping and pulping of green pine stumps at The Institute of Paper Chemistry. The former is no longer a novelty but the laboratory study was required to provide evidence of the effect which introduction of whole tree chips could have on established mill situations utilizing debarked stemwood.

As far as is known, there are no large-scale pulping operations in which stumps provide the major source of fiber. They have been salvaged and solvent extracted in the production of naval stores and attempts have been made to utilize pulps made from the extracted wood particles[1].

A review of the literature shows studies which suggest that the use of stumps (including the root systems) would increase the yield from the forest as much as 46%[2]. Others are more conservative. Wicklund[3] estimated that stump use would increase Sweden's fiber resources by 10% and Howard[4] determined that the stump made up 16.5% of the weight of an entire pine tree used in her investigation.

Mr. Peckham is Research Fellow and Mr. McKee is Senior Research Associate at The Institute of Paper Chemistry, Appleton, Wisconsin. The research was sponsored by the Fourdrinier Kraft Paperboard Institute and through their generosity the results were released for publication.

Fiber properties and pulp quality data reported vary but most authors agree that pulp fibers made from roots differ in morphology from stemwood fibers and make a weaker pulp, especially deficient in tearing strength[5,6]. A lower wood specific gravity was noted[4] without much change in extractives content. Matyushkina, _et_ _al_.[7] found higher yields of turpentine and tall oil when pine stumpwood was pulped to about 3.5% lignin content. Sproull, _et_ _al_.[8] and Matyushkina[9] reported the need for more alkali to cook rootwood as compared with stemwood.

The sample of slash pine stump chips used in The Institute of Paper Chemistry study came from a 14-year-old plantation in northern Florida. The stumps had been bulldozed from the soil, washed with a fire hose and chipped in a conventional chipper. A preliminary examination of the sample showed that considerable cleaning and size reduction would be required before the stumpwood could be pulped and the pulp safely introduced into pulp testing equipment. As a first step, a representative sample was screened on a Sweco screen and the fractions were weighed and categorized (Table I). It was difficult to identify rootwood chips from those representing the aboveground portion of the tree. The fine rootlets made up less than 1% of the wood weight. There was about 10% by weight of bark, some of which undoubtedly was associated with rootwood. The sample, after examination, was recombined and reduced to sawdust which was used as the raw material for the chemical tests, the results of which appear in Table II. Of particular interest here are the data showing the higher extractives and ash content of the stumpwood meal.

[Tables I and II here]

As preparation for pulping, a larger amount of the chip supply was screened and the part passing a 10-inch mesh screen was discarded. This included a good deal of sand. The oversize particles (obviously too large for digesting) amounting to more than 40% of the total chip weight, were further reduced in size by passing them through a 47-inch Carthage 4-knife chipper. A portion of the screened chips received a water wash in a tank fitted with a perforated false bottom. After agitation in the wash water the floating chips were reclaimed and partially air-dried. Parallel pulping experiments were carried out with the "screened" and the "washed" chips. A sample of the "screened" chips was tested for chip density and packing characteristics. There was considerable variation in the density of individual chips, from 0.212 to 0.672 (o.d. weight/green volume). The average was 0.379, which compares with a figure used by Isenberg[10] of 0.56 for debarked slash pine. A simple packing test, using a 1-cubic-foot box as a container, indicated that the stumpwood had a bulk density of 11.8 lb o.d./cu ft. This is considered to be fairly low since a similar test performed on typical pinewood mill chips gave a density of 16 lb/cu ft. Visual examination would assess much of this difference to the chip configuration, which was much coarser in the case of the stumpwood.

The kraft pulping experiments were carried out in a vertical stationary digester fitted for external heating of the circulated cooking liquor. The results, shown in Table III, demonstrated a consistently lower yield for the stumpwood pulps than for stemwood pulps, at any degree of delignification. This is demonstrated graphically in Figure 1. A better yield-Kappa number relationship resulted when the chips were washed before cooking, but this simply means that much of the material removed in the washing operation would have been dissolved by the cooking liquor. The pulping sequence represented by Cooks 3, 5, and 9 shows that extending cooking time in an effort to reduce pulp lignin content was not successful until the chemical dosage was increased. Since the 16% Na_2O level was adequate for pulping pine stemwood to 60 Kappa number or less, this was interpreted as demonstrating a higher chemical demand for stumpwood than for stemwood.

[Table III and Figure 1 here]

A number of the pulps were evaluated for strength properties and the data shown in Table IV were generated. It was noted that the stumpwood pulps were not as strong as stemwood pulps: the one exception was folding endurance, where the stumpwood pulps compared favorably with those made from stemwood. The degree of delignification did not have a major effect on pulp strength in the range studied. Figure 2 compares the tensile-tear relationships of a stemwood and a stumpwood pulp and shows the disparity in these properties between the two kinds of pulp.

[Table IV and Figure 2 here]

In another experiment, stemwood pulp was diluted with 10% stumpwood pulp and evaluated. Figure 3 shows that the tearing strength was markedly reduced.

[Figure 3 here]

The conclusions drawn were as follows:

1. Unbarked stumps contributed substantial amounts of extraneous organic material when reduced to chips for wood pulp manufacture.

2. Stumpwood chips were less dense, on the average, then stemwood chips.

3. Field dirt was present in significant amounts even though steps were taken to wash the stumps before chipping.

4. Pine stumpwood processed without debarking was high in extractives but the wood had the same lignin content as pine stemwood.

5. Kraft pulp from pine stumpwood appeared darker in color than that made from equivalent stemwood and was lower in yield at a given degree of delignification.

6. Because of its lower density, stumpwood can be expected to produce less pulp from a given digester volume than stemwood, even at the same yield.

7. Stumpwood will require a greater dosage of alkali for pulping but this should be recoverable along with probably enhanced amounts of tall oil and turpentine.

8. Stumpwood pulp can be expected to be inferior in most physical properties other than folding endurance when compared with a similar pulp made from conventional pine chips.

9. Dirt contamination is probably the most troublesome problem connected with high yield kraft pulping of pine stumps. Brown stock refiner plate surfaces will be the most vulnerable to increased wear, but the entire pulp mill system could be affected by the introduction of the soil and rocks physically retained by the root structure.

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Table I. Characterization of stumpwood fractions

	Airdry Weight, %	Hand Separated into Subfractions			
		Wood Only	Wood with Bark	Bark Only	Rootlets
Oversize	41.3	41.3	none	none	none
On 1-inch	19.7	19.2	0.1	0.4	none
On 0.5-inch	31.4	24.7	0.2	6.1	0.4
On 0.25-inch	5.3	2.8	none	2.3	0.2
Through 0.25-inch	2.3	0.4	none	1.9	Less than 0.05

Sweco screen, uniform feed rate

Table II. Chemical properties of slash pine

	Peeled Slash Pine	Stumpwood as Received	Screened Stumpwood Chips	Washed Stumpwood Chips
Alcohol-benzene extractives, %	1.88	5.45	4.9	5.0
Hot-water extractives, %	3.25	--	10.2	5.8
Lignin, %	--	27.4	--	--
Acid-soluble lignin, %	--	0.46	--	--
Ash, %	0.25[a]	1.58	0.99	0.94
Sugars, %				
Rhamnan	--	0.1	--	--
Araban	--	1.5	--	--
Xylan	--	3.8	--	--
Mannan	--	11.1	--	--
Galactan	--	25	--	--
Glucan	--	38.8	--	--

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[a] See Reference 10.

Table III. Cooking conditions and product variables

Kraft pulping of slash pine stumpwood

	Cooks						
	3	4	5	9	6	7	8
Kind of chips	Screened						
Active alkali (as Na_2O), %	16	16	16	18	16	16	16
Time at maximum temp., min	70	45	90	80	70	70	45
Kappa no.[a]	114	136	118	84.3	114	109	125
Unscreened yield, %	47.7	52.4	49.0	45.9	59.7	52.7	56.4
Spent liquor, pH	12.7	12.7	12.2	12.7	12.7	12.7	12.8
Constant conditions	25% sulfidity white liquor, 60 min to a maximum temperature of 172°C; water ratio, 4.0 to 1 — based on o.d. wood.						

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[a] TAPPI Standard T 236 m-60.

Table IV. Pulp properties

	Cook 4	Cook 3	Cook 9	Cook 8	Cook 7	Pine Stemwood[a]		Mixture
Pulp from	Screened stumpwood			Washed stumpwood		A	B	90% Pine stemwood and 10% Cook 7
Kappa no.	135	114	84	125	109	83	60	
Yield, %	52.4	47.7	45.9	56.4	52.7	61.5	51.7	
Properties at 700 ml CSF								
Beating time, min	39	22	8	43	28	39	43	26
Density, cc/g	0.581	0.533	0.637	0.566	0.591	0.557	--	0.56
Burst factor	46	44	47	44	47	54	69	57
Tear factor	112	121	135	124	138	162	176	172
Tensile breaking length, km	6.55	6.2	6.75	6.2	6.4	7.65	9.0	7.9
Fold MIT	800	660	1150	620	790	805	910	950
Tensile energy absorption, kg m/m^2	7.6	7.4	9.6	7.9	8.3	--	8.1	7.9
Stretch, %	2.8	2.9	3.4	3.3	3.0	2.4	--	2.3
Stiffness (Et)	321	330	336	295	310	451	--	410
Properties at 620 ml CSF								
Beating time, min	56	70	30	72	58	55	--	39
Density, cc/g	0.604	0.620	0.657	0.608	0.638	0.591	--	0.58
Burst factor	52	49	55	55	54	62	--	64
Tear factor	112	110	117	112	120	147	--	155
Tensile breaking length, km	7.2	7.5	7.85	6.55	7.33	8.4	--	8.5
Fold MIT	1030	1020	1550	780	1140	940	--	900
Tensile energy absorption, kg m/m^2	9.5	8.8	10.5	9.1	10.7	--	--	8.5
Stretch, %	3.1	2.9	3.3	3.2	3.3	2.8	--	2.5
Stiffness (Et)	389	343	390	382	319	480	--	430

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[a] Unpublished Institute research.

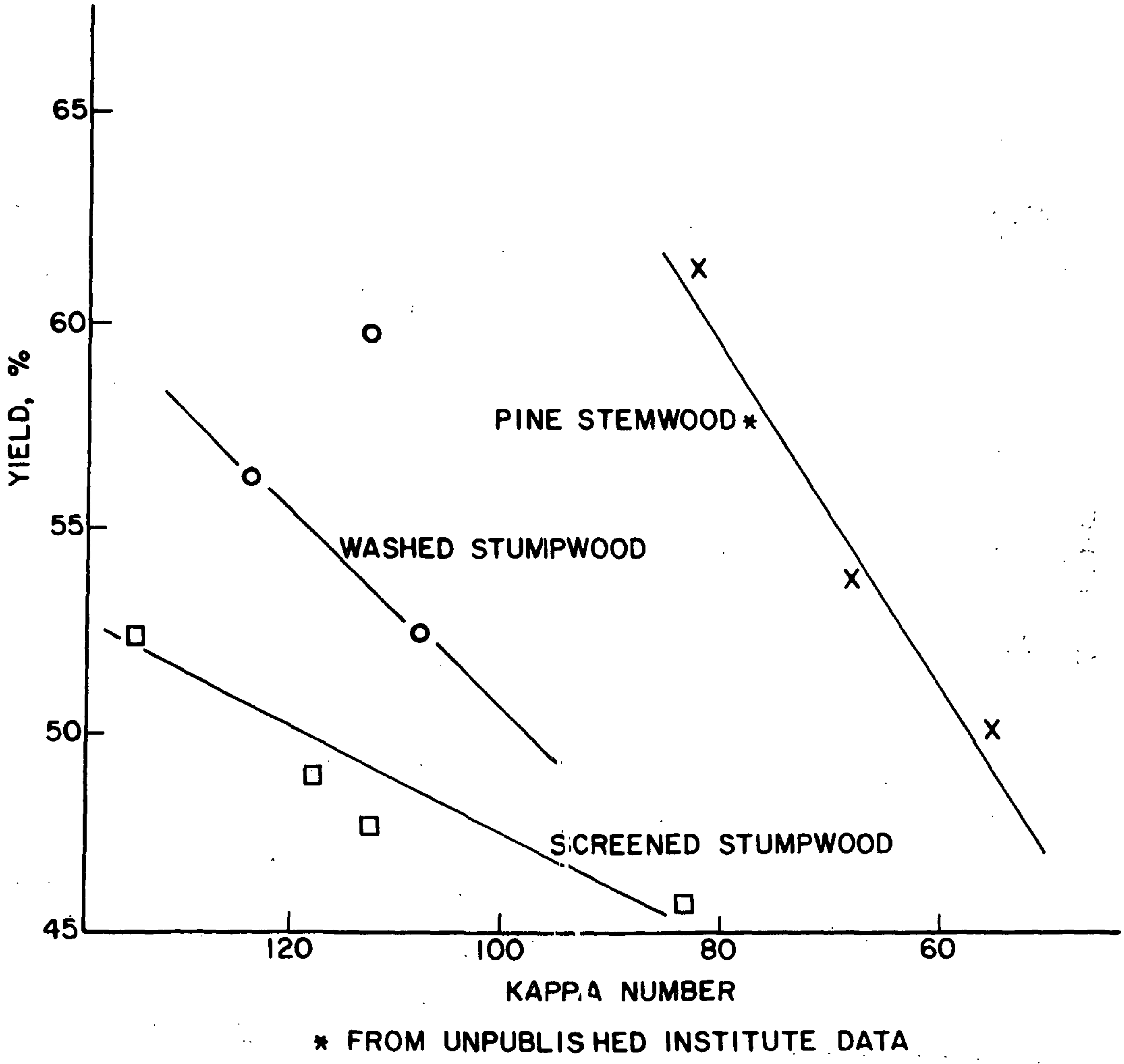

Figure 1. Yield of pulp vs. Kappa number.

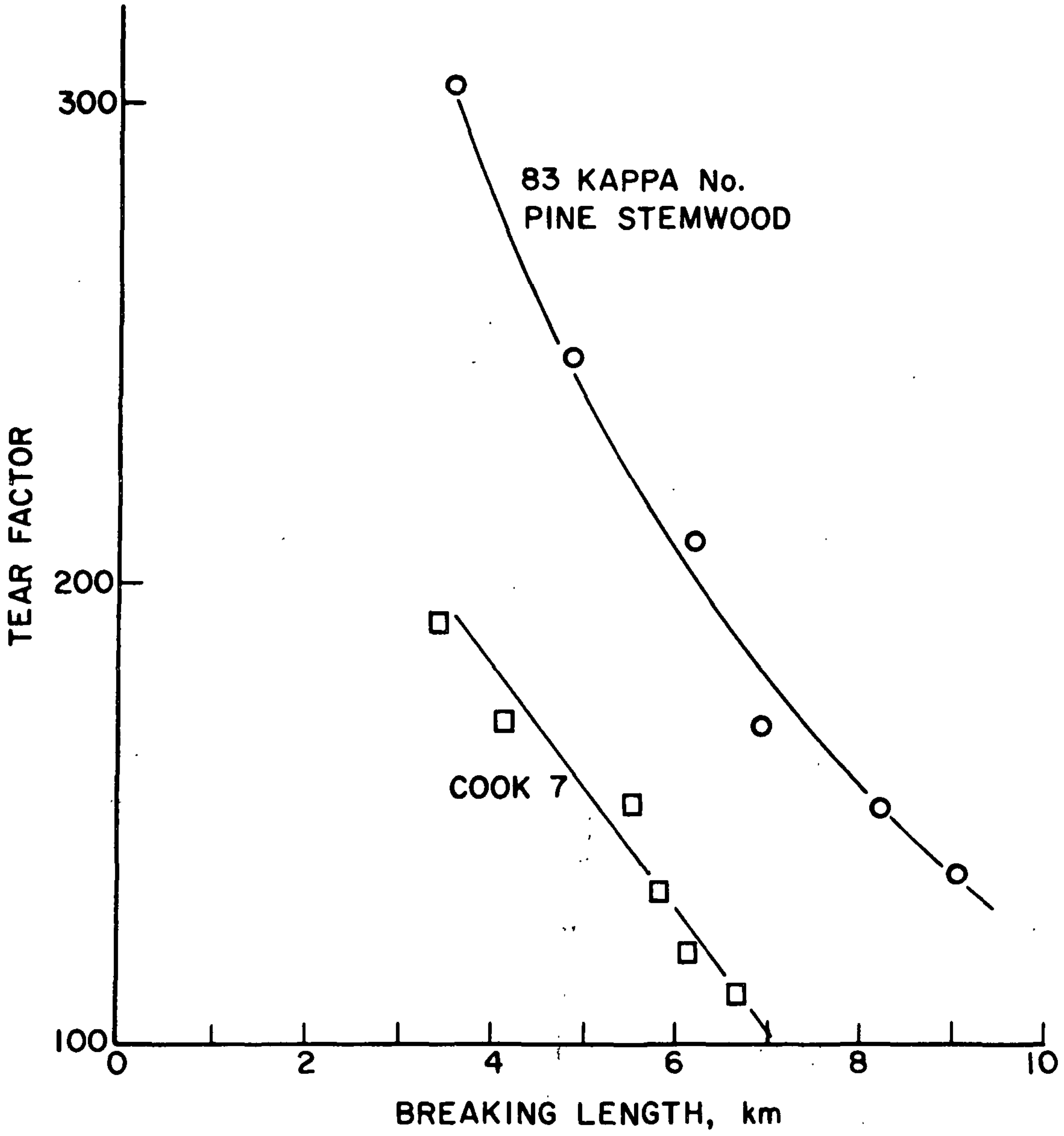

Figure 2. Comparison of pine stemwood and stumpwood.

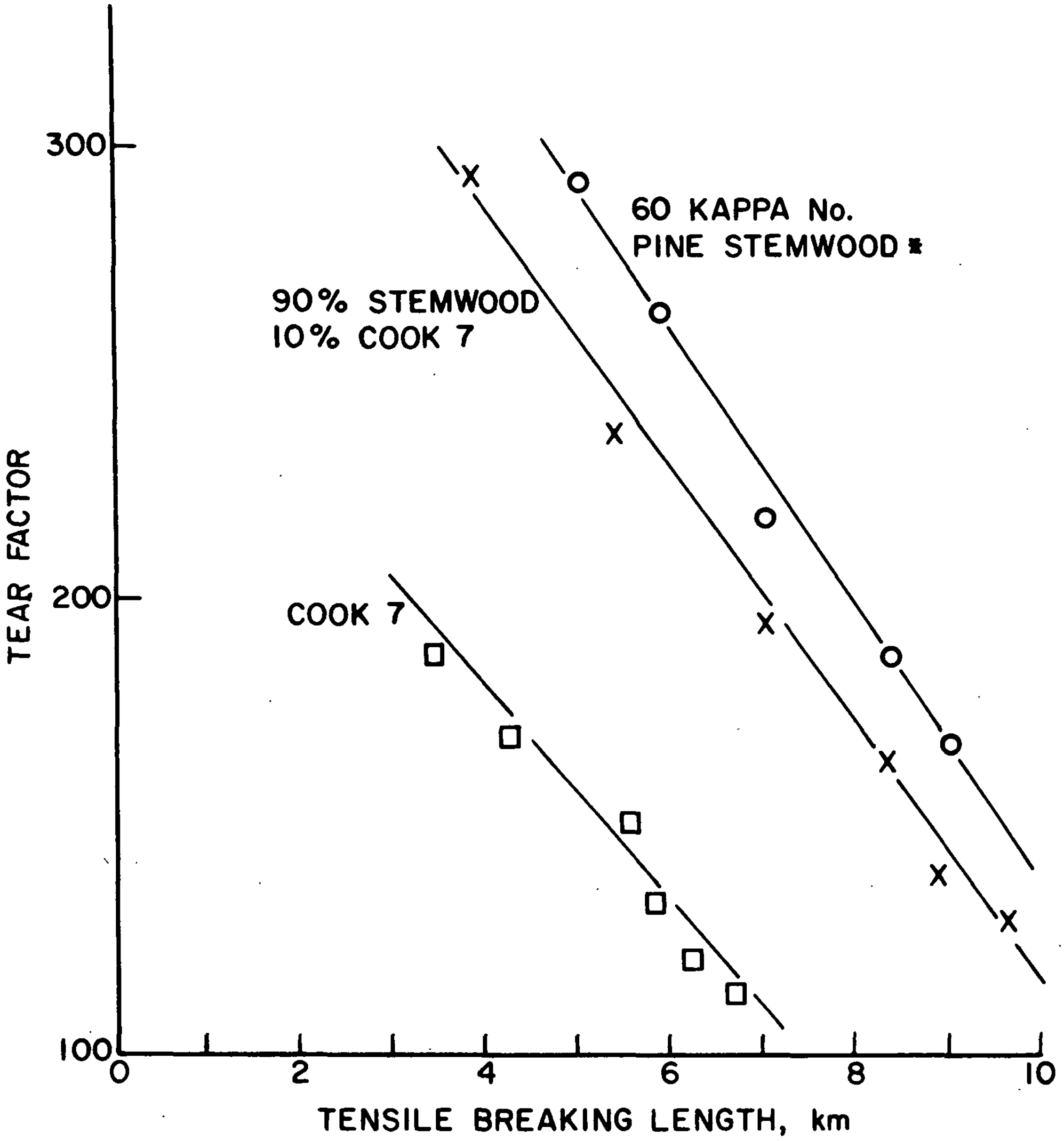

Figure 3. Tearing strength *vs.* tensile strength.