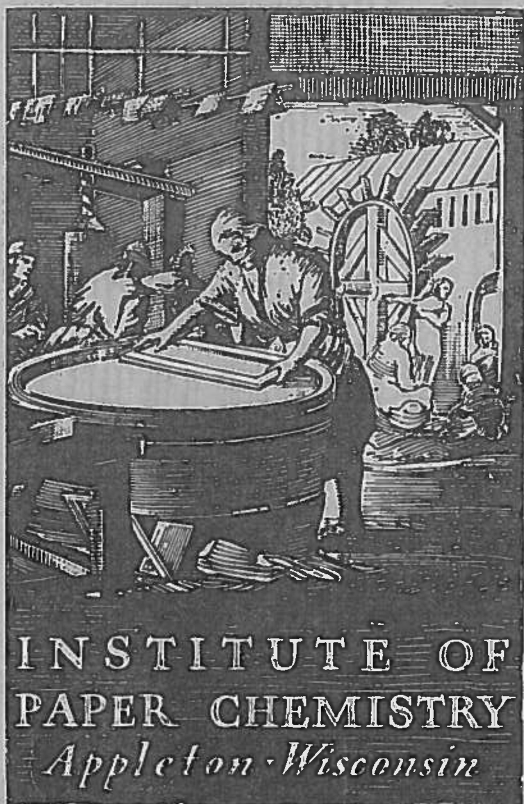

GENETIC IMPROVEMENT OF LARCH

Project 3409

Report Three

A Progress Report
to
MEMBERS OF GROUP PROJECT 3409

March 10, 1983

LARCH AS A SOURCE OF KRAFT PULP

Introduction

There have been several pulping studies conducted in the last four years on Lake States-grown conifers, including the Project 3409 "larch" studies, that present an interesting story concerning the usefulness of European, Japanese, and hybrid larch as a source of kraft fiber. The studies include the investigations reported in Project 3409, Progress Reports One and Two, and work completed on juvenile jack pine and Eastern larch (*Larix laricina*, K. Koch) as part of a cooperative study with the U.S.F.S., Rhinelander, Wisconsin. Also, an Institute member company completed a very useful kraft pulping study on plantation-grown red pine* and jack pine that provides additional insight into the quality of Lake States plantation-grown conifer fiber. Permission was obtained to use part of those data, and it is the intent of the report that follows to compare larch, jack pine, and red pine pulping data and present an overview on the usefulness of larch fiber.

Pulping and Bleaching

One early concern about the use of European and Japanese larch for pulp was associated with extractive levels. If extractive levels were as high as reported in the literature, then pulp yield could be expected to be low and there would very likely be bleaching problems, either low brightness or high chemical requirements. The comments in the two sections that follow deal with the types of wood samples used in the several pulping studies undertaken and the kraft pulp yields obtained. The third section reviews the bleaching results obtained, and the final major section discusses the pulp strength data for kappa 50 and kappa 30 pulps.

*Red pine, which is also called Norway pine, *Pinus resinosa* Ait., is the most commonly planted Lake States conifer.

Sources of Wood

The wood sources used in the pulping work being summarized are described in Table IX. Of particular importance is the influence of tree species, age, and the presence of bark on resulting quality of chips and pulps produced. The only experimental materials that require some explanation are the three short rotation chip samples. They are from relatively small-size trees in which the entire above ground part of the tree was chipped (whole tree chips). For the hybrid larch, the bark content was reduced by screening and needle content kept to a minimum by removing most of the needles prior to chipping. The short rotation jack pine and short rotation Eastern larch were whole tree chips in which a vacuum air lift chip quality enhancement procedure was used to remove needles, bark, and other types of fines. The chip quality of the latter two sources was then further upgraded by screening and discarding material passing the 1/4-inch screen.

Pulp Yields and Kappa Number

Adequate pulp yields are all important in the selection of new pulping species. Typical kraft pulping procedures were used in these comparisons and the details, although not presented in this report, can be obtained from Project 3409 Progress Reports One and Two, and from a publication by Isebrands (3)*. Table X summarizes the pulp yields obtained. To assist the reader in comparing the yields of the various sources of wood, the unscreened yield data were adjusted to kappa 35. Using adjusted unscreened pulp yield data, jack pine has a pulp yield of 44-45%, red pine a pulp yield of 45-46%, Japanese larch a pulp yield of 45-46%, European larch a pulp yield of 48%, and hybrid larch a 49% yield. The eight-year-old whole tree chips which had from 2 to 23% bark had adjusted yields from 33 to 39%.

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*Pulping conditions for the red pine pulps and the 25-year-old jack pine pulp were essentially identical to those for the larch pulps in Progress Reports One and Two.

TABLE IX

SUMMARY OF WOOD SOURCES

Wood Sample Description	Age, years	Bark, %	Specific Gravity (green volume basis)	Extractives, %	
				Alcohol/Benzene	Hot Water
Red pine stud bolts[a]	57	0	0.44	--	--
Jack pine pulpwood bolts	55	0	0.44	3.5	2.3
Red pine plantation trees[a]	22	0	--	--	--
Jack pine plantation trees[a]	25	0	0.39	--	--
European larch plantation trees	18	0	0.40	1.8	3.9
Japanese larch plantation trees	22	0	0.38	3.0	7.4
Hybrid larch plantation trees	23	0	0.41	2.5	4.2
Hybrid larch int. mang. trees[b]	8	23	0.34	2.4	7.4
Jack pine short rotation trees[b]	8	2	0.34	3.8	--
Eastern larch short rotation trees[b]	8	8	0.38	--	--

[a] Institute member company study.

[b] Part of cooperative study with U.S Forest Service - trees were from their short rotation intensive culture research program. The chips of the jack pine and eastern-larch were upgraded by vacuum air flotation and screening.

TABLE X

SUMMARY OF KRAFT PULP YIELDS

Wood Sample Description	Kappa No.	Unscreened Yield, %	Rejects, %	Pulp Fiber Length, Arith. Av., mm
Red pine stud bolts	40	46 (45.2)[a]	--	--
Jack pine pulpwood bolts	49	47 (44.9)	0.9	1.9
	34	44 (44.2)	0.6	1.9
Red pine plantation trees	35	46 (46)	--	--
Jack pine plantation trees	35	45 (45)	--	--
European larch plantation trees	53	51 (48.3)	11	1.6
	31	47 (47.6)	0.3	1.6
Japanese larch plantation trees	56	48 (44.8)	5.1	1.8
	32	46 (46.4)	2.2	1.8
Hybrid larch plantation trees	53	52 (49.3)	2.2	1.8
	35	49 (49)	1.4	1.7
Hybrid larch int. mang. trees	55	36 (33)	1.0	1.6
Jack pine short rotation trees	51	41 (38.6)	--	1.2
Eastern larch short rotation trees	49	39 (36.9)	--	1.2

[a]Yield adjusted to kappa 35.

European and the bark-free, 23-year-old hybrid larch had the best pulp yield of the chip sources investigated. Both sources, however, had high reject levels when pulped to kappa 50, and would require the repulping of rejects to attain the yield levels indicated. European and hybrid larch reject levels were normal when pulped to kappa levels of 31 to 35. Japanese larch yields were equivalent to those of red pine and were about 1% better than those of jack pine.

Bleaching Results

Another area of concern associated with the use of larch was the possible bleaching difficulties that might be encountered due to hot water extractives levels. Kappa 30 pulps were used in evaluating bleach requirements. A CEDED bleaching sequence was used, and Table XI summarizes several comparisons which provide some insight into the bleaching characteristics of larch. Each of the plantation sources of larch, and pulp that contained 25% pulp from the intensively managed 8-year-old hybrid, required more bleaching chemicals and had a lower final brightness than the jack pine control pulps. The 23-year-old hybrid larch plantation trees produced pulps that were most like jack pine in bleach requirements. Japanese larch pulps and pulps prepared from 8-year-old hybrid larch (23% bark) were the most difficult to bleach. The bleaching of pulps from 20- to 25-year-old larch does not appear to be a major problem but will be a little more costly than the jack pine control pulps because of the higher amount of chemical required to reach a specific brightness.

Pulp Strength Comparisons

Kappa 50 pulps that could be used for bag papers and kappa 30 pulps suitable for use in bleachable grades of paper and board were evaluated by preparing standard beater curves. Comparisons between the several sources of larch pulps and the red pine and jack pine control pulps are best made by plotting pulp strength at several different freeness levels and/or sheet densities. Another simpler, yet useful, approach is to compare pulp strength (tear, burst, tensile, etc.) at a constant sheet density. This approach was used to compare the several pulp sources described in Tables IX and X, and the results are presented in the sections that follow. Additionally, selected pulps were also evaluated by plotting tear factor over breaking length, which allows tear to be compared at a constant breaking length.

TABLE XI

BLEACHING RESULTS FOR KAPPA 30 PULPS
CEDED

Wood Pulp Description	Kappa No.	Chlorine Consumed, %	Chlorine Dioxide Consumed, %	Final GE Brightness %
Jack pine pulpwood bolts	34	7.0	1.60	90.3
European larch plantation trees	31	7.3	1.84	88.2
Japanese larch plantation trees	32	7.3	1.85	84.4
Hybrid larch plantation trees	35	7.0	1.53	88.3
75% Jack pine, 25% hybrid larch int. mang. trees	34	8.3	1.54	84.6
75% Jack pine, Japanese larch plantation	35	7.5	1.72	87.9
75% Jack pine, 25% European larch plantation	31	7.2	1.53	89.5
75% Jack pine, 25% hybrid larch plantation	31	7.0	1.50	90.2

Kappa 50 Pulps

Table XII summarizes the handsheet strength properties of the kappa 50 pulps. For use as bag papers, tear factor and tensile energy absorption (TEA) are very important. To facilitate comparisons of these properties, the

TABLE XII

KAPPA 50 UNBLEACHED PULP STRENGTH COMPARISONS[a]

Pulp Sample Description	Age, Years	Kappa No.	Pulp CSF, mL	Sheet Density	Breaking Length, km	Burst Factor	Tear Factor	TEA, kg M/m^2
Jack pine pulpwood bolts (control)	55	49	510	0.72	10.8	87	122 (100)[b]	14.6 (100)[b]
European larch plantation trees	18	53	445	0.72	11.0	84	114 (93)	14.7 (101)
Japanese larch plantation trees	22	53	210	0.71	10.8	86	115 (94)	15.5 (106)
Hybrid larch plantation trees	23	56	280	0.71	10.2	83	141 (116)	14.6 (100)
Hybrid larch int. mang. trees	8	55	330	0.69	8.9	66	99 (81)	13.9 (95)
Eastern larch short rotation trees	8	49	400	0.72	10.5	78	84 (69)	--
Jack pine short rotation trees	8	51	400	0.72	9.8	69	80 (66)	--

[a]Comparisons made at comparable sheet density.
[b]Values in parentheses are percentages of the jack pine pulpwood control pulps.

55-year-old jack pine strength values for tear factor and TEA were given a value of 100 and relative values calculated for the other sources of pulp. Unfortunately kappa 50 pulp data were not available for the red pine and jack pine plantation wood. Comparing kappa 50 values for tear factor, the hybrid larch plantation pulps (23-year-old trees) had the highest value (116) and the short rotation jack pine (8-year-old trees) the lowest tear (66). European and Japanese larch plantation tree tear factor values were 6-7% lower than those of the jack pine control pulp. Comparing TEA values, the data for the short rotation trees were not available, and the differences in TEA for other sources of pulp varied very little (95 to 106) from that of jack pine control pulps. Burst factor was lowest for the short rotation (juvenile) pulp sources, and 18- to 23-year-old larch plantation trees had values that were comparable to the jack pine control pulp.

When tear factor was plotted over breaking length (Fig. 6), the hybrid larch plantation pulps had the highest tear factor/breaking length combination; the values for European larch and Japanese larch plantation pulps appeared comparable to the jack pine control pulp; and the three short rotation (juvenile pulps) had the poorest tear factor/breaking length strength values.*

Kappa 30 Pulps

Table XIII summarizes the available handsheet strength data for the kappa 30 bleached pulps. The comparisons in this instance, as with the kappa 50 pulps, were made at comparable sheet density (0.70 - 0.72 g/cc).** Using this approach, there was a moderate amount of variation in pulp freeness levels, i.e., from 325 to 670. Pulps from short rotation trees were not part of this comparison because of the anticipated bleaching problems associated with whole tree chips containing varying levels of bark. The only exception to this statement is that a mixture of 75% jack pine control chips was cooked with 25% 8-year-old hybrid larch chips, and the resulting 30 kappa pulp was bleached and tested for strength properties (Table XIII).

*Pulps are refined to improve breaking length. Refining causes a loss in tearing strength. Pulps that develop good breaking length (8 to 10 km) and retain high tear are considered superior.

**Except for the red pine plantation tree pulps, which had a sheet density of 0.75.

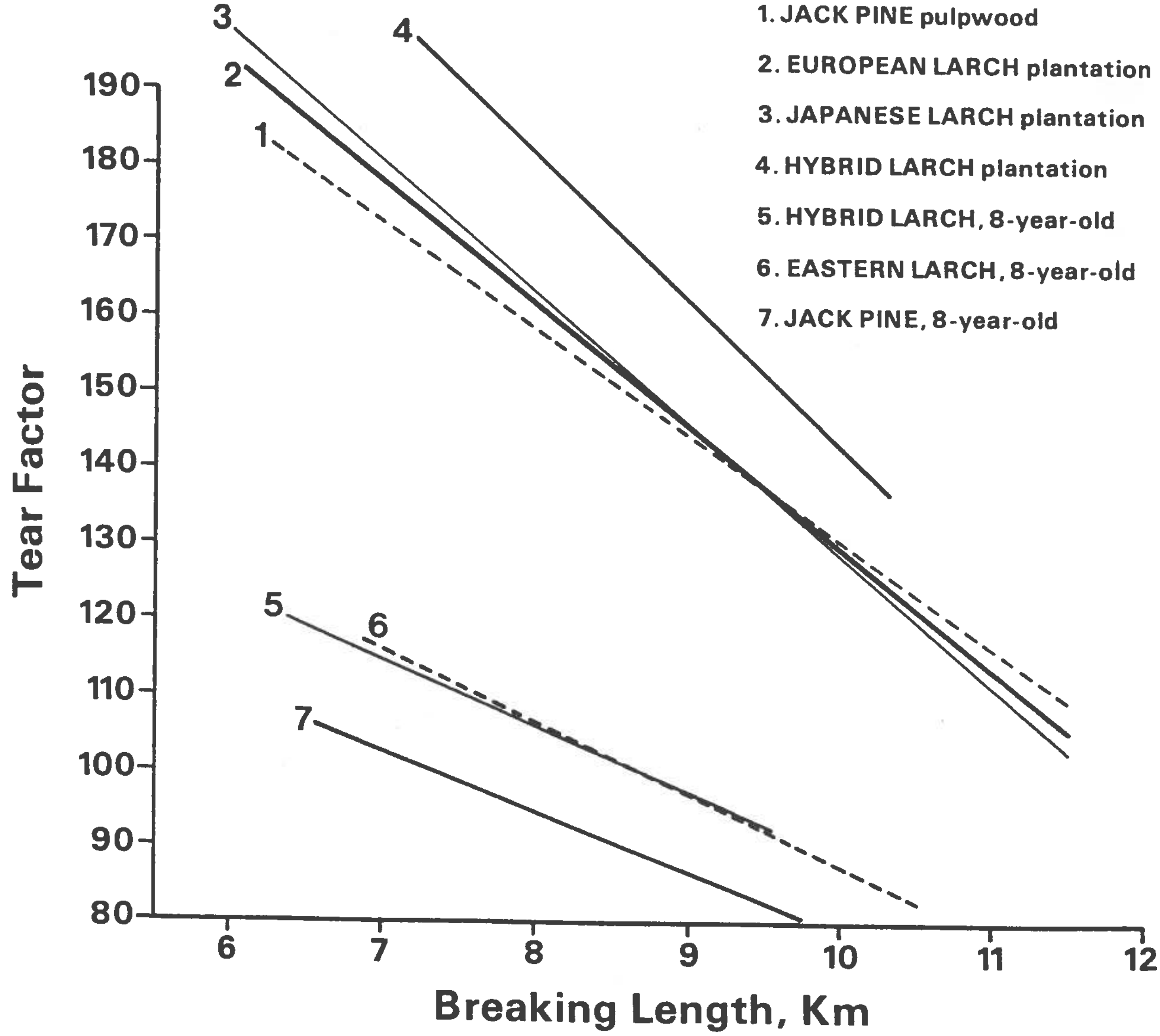

Figure 6. Tear factor vs. breaking length at 50 kappa.

TABLE XIII

KAPPA 30 BLEACHED PULP STRENGTH COMPARISONS[a]

Pulp Sample Description	Age, Years	Kappa No.	Pulp CSF, mL	Sheet Density g/cc	Burst Factor	TEA, kg M/m^2	Breaking Length, km	Tear Factor
Jack pine pulpwood bolts (control)	55	34	640	0.71	85	17.8	10.2 (100)[a]	136 (100)[a]
European larch plantation trees	18	31	620	0.71	74	14.8	10.2 (93)	161 (118)
Japanese larch plantation trees	22	32	465	0.72	90	17.9	11.4 (112)	126 (93)
Hybrid larch plantation trees	23	35	325	0.72	89	16.8	11.0 (108)	144 (106)
				* * * * * * *				
75% jack pine, 25% hybrid larch (int. mang. trees)	55 8	34	670	0.70	73	15.3	9.1 (89)	154[b] (113)
Red pine plantation trees	22	35	500	0.75	74	--	8.6 (84)	97 (71)
Jack pine plantation trees	25	35	475	0.72	75	--	8.7 (85)	117 (86)
Red pine stud bolts	57	40	465	0.71	84	--	8.8 (86)	145 (107)

[a]Comparisons made at comparable sheet density; values in parentheses are percentages of the jack pine pulpwood bolt control pulps.

[b]This value is misleading - upon further refining sheet density increased rapidly and tear factor decreased to values comparable to those of the jack pine control pulp.

Breaking length and tear factor are important to bleachable grade pulps. To facilitate the comparison of these two properties, the jack pine control pulps were assigned a value of 100, and the tear and breaking length data for the other sources of pulp were given values that were percentages of the jack pine control pulps (see values in parentheses in Table XIII). When tear factor values for the different types of pulps are compared, the pulp from European larch plantation trees (age 18) had the highest tear and the red pine plantation pulps (age 22) had the lowest tearing strength (29% less than the jack pine control pulps). When this same comparison is made for breaking length, the Japanese larch pulps had the highest value, and the red pine plantation pulps again had the lowest value. An interesting and somewhat unexpected result was the high tear and the acceptable breaking length values obtained for pulp produced from the mixture of 75% jack pine and 25% juvenile hybrid larch. This higher than expected tear value, however, was associated with a low level of refining. At higher refining levels tear factor decreased and was similar to the jack pine control pulp.

To provide an additional insight into the differences between the kappa 30 pulps, tear factor was plotted over breaking length for selected pulps. These results are summarized in Fig. 7*. Pulps that develop adequate breaking length (upon refining), yet maintain good tearing strength are generally considered to be superior to those pulps that develop adequate breaking length but, as a result,have low tearing strength. When these comparison criteria were applied, the red pine and jack pine plantation pulps were the least desirable, and the hybrid larch plantation (age 23) pulps and Japanese larch plantation (age 22) pulps appeared to be a little better than the jack pine control pulps and the most desirable of pulps evaluated.

*Except the red pine plantation tree pulps which had a sheet density of 0.75.

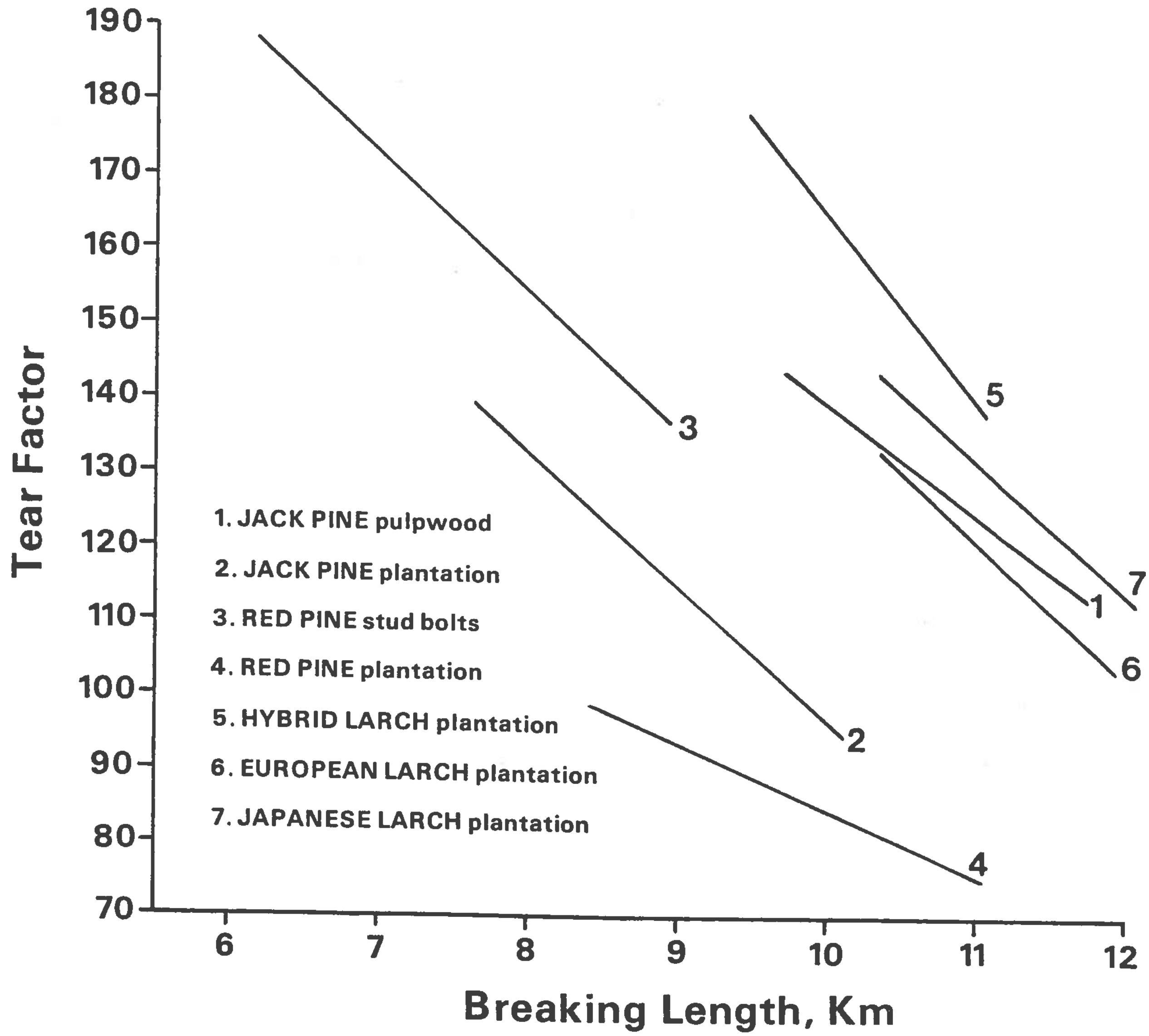

Figure 7. Tear factor vs. breaking length for 30 kappa bleached pulps.

In many instances the reason for adding the conifer fiber to hardwood pulps is to improve tearing strength and breaking length (tensile strength). One reason this is important is that wet strength is improved and machine speed can be increased. The kappa 50 and kappa 30 comparisons indicate that European, Japanese, and hybrid larch are superior to comparable-age jack pine and red pine for addition to hardwood pulps. The use of red pine thinnings for pulpwood is expected to increase; as this occurs, the inferiority of red pine as pulpwood will become more and more evident.* This is no small matter when one considers the millions of red pine being planted each year in the Lake States and Northeast.

Pulps from Jack Pine/Larch Mixtures

Knowing that in most instances larch will not be pulped alone, mixtures of 75% jack pine and 25% larch were prepared and evaluated. Chip mixtures were pulped and evaluated in studies involving the chip sources of European larch plantation trees, Japanese larch plantation trees, hybrid larch plantation trees, and the intensively managed 8-year-old hybrid larch (Table XIII). Details of these comparisons are not presented at this time but can be obtained from Project 3409, Progress Reports One and Two, and publications by Isebrands *et al*. (3) and Einspahr *et al*. (4).

The results of this chip mixture approach produced few surprises. No problems were encountered in cooking rate, rejects, or pulp yields. Values for most parameters measured were intermediate between those for the jack pine control and the values for the larch chip sources when pulped alone, usually being closer to those of the jack pine control.

*It should be noted that these conclusions are based upon a limited amount of data and should perhaps be rechecked in view of the implications.

Refining rates, sheet density, and handsheet strength properties also followed a similar pattern, i.e., being intermediate but more nearly equal to the jack pine control pulp values. The one somewhat unexpected result was the considerable improvement in the strength (particularly tear factor) that occurred when the relatively low quality juvenile hybrid larch chips were cooked with 75% jack pine control chips. This was apparently due in part to the better bonding imparted by the juvenile thin-walled fibers of the 8-year-old hybrid larch. This pulp mixture, however, did not respond well to refining and at lower freeness levels and higher sheet densities had lower tear than the other pulps.

Pulping Summary

Based upon the information presented in this report, and the data presented and discussed in Project 3409, Progress Reports One and Two, the following conclusions concerning larch kraft pulps were obtained:

1. Hybrid larch chip sources and chip mixtures with jack pine cooked at rates similar to the jack pine control chips.

2. European larch chips and the chip mixture with jack pine cooked at rates modestly faster than the jack pine control chips.

3. The Japanese larch chips and the chip mixture with jack pine cooked at a slightly slower rate than the jack pine control chips.

4. The unscreened pulp yields for all chip sources were adjusted to a kappa number of 35. The resulting adjusted yields were as follows: jack pine - 44 to 45%; red pine - 45 to 46%; Japanese larch - 45 to 46%; European larch - 48%; and hybrid larch - 49%.

The juvenile (8-year-old) whole tree hybrid larch and Eastern larch had adjusted yields of 33 and 37%, respectively.

5. Cooking larch chips and chip mixtures containing 25% larch to kappa 50 resulted in larger than acceptable levels of screen rejects that dropped to normal levels by cooking to kappa 30 to 35.

6. European larch refined at similar rates and had kappa 50 pulp strengths that were comparable to those of the jack pine control pulps, whereas hybrid and Japanese larch refined with more difficulty and developed lower kappa 50 breaking length.

7. When compared to the jack pine control pulps, Japanese larch had similar, and hybrid larch had greater, kappa 50 tearing strength.

8. Tensile energy absorption of the larch kappa 50 pulps, an important property of bag and wrapping papers, was comparable to the values for the jack pine control pulps.

9. When compared to the jack pine control pulps, kappa 50 pulps from the juvenile sources of larch (and jack pine) had 20-35% lower burst and tearing strength and similar breaking length values.

10. The hybrid larch kappa 30 pulp (age 23) had bleaching chemical requirements and a final brightness not greatly different from those of the jack pine control pulps.

11. The European larch kappa 30 pulp was slightly more difficult to bleach; the Japanese larch kappa 30 pulp and the kappa 30 pulp containing 25% juvenile hybrid larch pulp (23% bark) were the most difficult to bleach.

12. Pulping larch and larch/jack pine mixtures containing European, Japanese, and age-23 hybrid larch to kappa 30, followed by bleaching, resulted in pulps that refined and had strength properties very similar to those of the jack pine control pulps.

13. When kappa 30 bleached pulps from larch were compared with comparable-age red pine and jack pine plantation pulps, the larch pulps were superior in tear, burst, and breaking length. Red pine plantation pulps had about 29% lower tear and 16% lower breaking length than the jack pine control pulps.

14. Limited tests, in which larch kappa 30 pulps from the 18- to 23-year-old plantation trees were mixed with hardwood pulps, demonstrated that larch could be satisfactorily substituted for the 55-year-old jack pine kappa 30 control pulp.