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A.W.J. Sinclair*
R. Berlyn**
G. Manning***

* Forest Engineering Research Institute of Canada
201-2112 W. Broadway
Vancouver, B.C. V6K 2C8

** Pulp and Paper Research Institute of Canada
570 St. John's Blvd.
Pointe Claire, Quebec H9R 3J9

*** Pacific Forest Research Centre
506 W. Burnside
Victoria, B.C. V8Z 1M5

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PREFACE

This report results from a joint venture project between the Canadian Forestry Service, the Pulp and Paper Research Institute of Canada and the Forest Engineering Research Institute of Canada. Most of the funding was supplied by the Canadian Forestry Service through the ENFOR program but all agencies cooperated by supplying facilities and personnel.

The authors wish to thank both Weyerhaeuser Canada Ltd. and its parent, Weyerhaeuser Company, for their excellent cooperation. They allowed us access to their mills and equipment at only a nominal charge and their personnel were very helpful in completing the tests. Thanks also go to Dr. J.V. Hatton of PPRIC for technical and editorial advice.

The exclusion of certain manufactured products does not imply rejection nor does the mention of other products imply endorsement by the Canadian Forestry Service.

FERIC FOREST ENGINEERING RESEARCH INSTITUTE OF CANADA
INSTITUT CANADIEN DE RECHERCHES EN GÉNIE FORESTIER

201 — 2112 West Broadway
Vancouver, B.C.
V6K 2C8

Energy ENFOR from the Forest

Canadian Forestry Service
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ABSTRACT

Sheared, decadent hemlock and cedar logging residues from a test of the Nicholson Residue Shear were chipped and upgraded (bark, rot and fines removed) to determine their suitability for pulping. In one test bolts were chipped with bark on, and the resulting material upgraded through the Paprifer process. In a second test, bolts were debarked in a drum debarker, then chipped. In both cases, rot remained at unacceptably high levels. Drum debarking reduced bark to acceptable levels; however, the Paprifer process did not remove sufficient bark, possibly due to dry, refractory bark. Further work is required on methods to remove rot from sheared, decadent material.

RÉSUMÉ

Les résidus d'abattage de pruches et de thuyas dépérissants obtenus lors d'un essai de la cisaille à résidus Nicholson ont été déchiquetés et améliorés (enlèvement de l'écorce, de la pourriture et des fines) en vue de déterminer s'ils pouvaient être utilisés pour la fabrication de pâte. Dans un essai, les billes non écorcées ont été fragmentées, et le matériel obtenu a été amélioré par le procédé Paprifer. Dans une deuxième expérience, des billes ont été écorcées à l'aide d'une écorceuse à tambour, puis fragmentées. Dans les deux cas, la pourriture qui restait était trop élevée. L'écorcage au tambour a réduit l'écorce à un degré acceptable, mais le procédé Paprifer n'enlevait pas suffisamment d'écorce, peut-être parce que celle-ci était sèche. D'autre travaux sont nécessaires sur les méthodes d'élimination de la pourriture sur le matériel dépérissant cisaillé.

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INTRODUCTION

The decadent cedar-hemlock stands in the B.C. Interior wet belt cover an estimated 240 000 ha of potentially productive land. Growth in these stands is zero or negative, and widespread heart rot, pocket rot and ring shake make the timber unattractive for sawlog use relative to fir, pine, spruce and other conifers. The heart rot and pocket rot also make them undesirable for pulp chips.

When these stands are harvested, the normal practice is to fall and remove the sawlogs and then to fall the non-merchantable logs remaining in the setting. Depending on the site, the felled non-merchantable timber may be left in the setting or skidded to the landing. If the former is the case, then post-logging silvicultural treatment becomes more difficult and expensive. If the material in the settings could be economically removed and utilized, then silvicultural costs would decrease and a source of energy or wood fibre would be developed. However, at present (1984) there is no market for the pulp chips, hog fuel or pulp logs which are the major products of decadent stands.

In the summer of 1982, the B.C. Ministry of Forests, under contract to the Pacific Forest Research Centre of the Canadian Forestry Service, tested the Nicholson Residue Shear (Fig. 1) near Lumby, B.C. The purpose of this test, funded by the ENFOR[1] program, was to determine the productivity and costs of processing logging residues from a typical decadent cedar-hemlock stand into material suitable for hogging as an energy source. The details of this trial are described in Oakley and Manning (1984).

During the field tests of the Nicholson Residue Shear it was hypothesized that if pulp chips as well as hog fuel could be recovered from the sheared residues then the economics of harvesting decadent cedar-hemlock stands would improve. The market price for pulp chips varies with supply and demand, but in recent times has ranged from $25 to $70 per bone dry unit (BDU)[2] or $23 to $64 per tonne. In comparison, in the same period hog fuel sold for $1.00 to

[1] ENFOR is the bilingual acronym for the CFS's ENergy from the FORest program.

[2] 1 BDU — 1089 kilograms (oven-dry basis)

Fig. 1. Nicholson Residue Shear

Fig. 2. Sheared Bolts of Decadent Cedar and Hemlock

$3.00 per tonne. Although somewhat higher costs would be incurred for debarking, chipping and screening to recover pulp chips, higher market prices might offset these additional costs. There could be an opportunity to improve the return from logging residues.

TEST LOCATIONS AND DESCRIPTION

Two tests were undertaken. In the first, bolts of green and dry hemlock and cedar (Fig. 2) were processed in four separate runs through a disc chipper and chip screens at the Weyerhaeuser Company's Lumby, B.C. sawmill. No attempt was made to remove bark and rot before chipping. Samples of the chips were then sent to the PPRIC's Pointe Claire laboratory for upgrading in the Paprifer pilot plant (Berlyn *et al.* 1979) with the intention of reducing the bark and rot content of the chips.

When the Nicholson shear cuts logging residues it also splits them if they are sufficiently short. Once split, the heart rot is exposed which should enable a drum debarker to remove exposed rot as well as bark. Consequently, the second test involved processing sheared bolts of green hemlock and cedar in separate runs through a small drum debarker before chipping and screening. Hog fuel was also produced. These tests were conducted at the Weyerhaeuser Company's Green Mountain Sawmill at Toutle, Washington. Both of these tests were coordinated and conducted by FERIC.

MATERIALS AND METHODS

Sheared Logging Residues

The sheared logging residues were sampled to determine size distribution before the chipping tests. The sheared residues constituted the raw material used in both the Lumby and the Green Mountain trials.

To quantify the physical characteristics of the sheared material, 27 random samples were measured using a statistical quartering[3] technique. In

[3] W.G. Warren - FORINTEK Canada Corporation — private communication, 1976.

total, approximately 50 m³ of sheared residue was sampled. Table 1 shows the size distribution of the sheared material produced by the mobile shear. The length at which the shear cuts the residue was varied to determine the effect of shearing length on productivity and on the amount of linear splitting of the sheared bolts. The sheared bolts used in both the chipping trials were selected from material produced when the shear was processing residues to a nominal length of 1.2 m.

In general, approximately 85% of the material (by weight) was between 60 and 200 cm and 14% was less than 60 cm in any dimension. About 5% of the material measured less than 15 cm, which mostly resulted from starting and ending cuts. All the processed material required secondary treatment, i.e., hogging or chipping, before it could be used in a wood-fired boiler or pulp mill.

Lumby Chipping Tests

The tests conducted at the Weyerhaeuser Co. Ltd. sawmill in Lumby, B.C. involved chipping of residues with none of the bark or rot removed, and used dry logging residues as well as green material. The main objectives were to determine chip quality and to obtain a supply of non-upgraded chips for testing by the Paprifer process.

Equipment and Procedures

Material was sheared to an average length of 1.2 m and transported to Lumby via container truck. The material was hand-piled cordwood fashion (Fig. 3) to determine the volumes, which were as follows:

Green hemlock	11.3 m^3
Dry hemlock	13.2 m^3
Green cedar	12.4 m^3
Dry cedar	12.3 m^3

These volumes were processed through a 147-cm diameter, six-knife, top discharge Bush Chip Master disc chipper powered by a 150-kW electric motor.

Because of chipper inlet restrictions, the maximum size of piece piled was 30.5 cm in diameter. Pieces of bark, chunks of rot, broken ends, and

Fig. 3. Piles of Sheared Residues

slabs were included in the piled material to give a representative sample. This material was transported to the chipper using the bucket of a front-end loader.

Each of the four types of material was chipped separately. The knives were changed both after the dry hemlock and dry cedar test, again after the green cedar test and were ready for a change after the green hemlock test.

Chip samples were taken at the outlet of the chip hopper before the screens and at the accepts outlet of the chip screens. Moisture content, chip size distribution, and bark and rot content were determined. Samples for the Paprifer tests were taken at the outlet of the chip hopper prior to discharge onto the chip screens.

Analysis of Chip Output

The chip samples were analyzed by FERIC at PPRIC's Vancouver laboratory. They were screened on a reciprocating Wennberg chip classifier fitted with four screens: 45-mm round holes, 10-mm slots, 7-mm round holes, 3-mm round holes and a bottom pan. The fractions collected were, respectively, oversize, overthick, accepts, pin chips and fines. The first two fractions were combined to give overs. Knots, bark and rot were hand sorted from the overs, accepts and pins fractions. The results are given in Table 2.

Approximately 60% of the chips produced were of a size acceptable for pulp chips and the remainder were acceptable as energy chips. Rot and bark contents on a percentage basis were not significantly reduced by screening and remained higher than pulp mills usually accept. However, the high percentage of rot and bark may be overcome at a pulp mill by blending high-quality chips with those of lesser quality.

Bark and Rot Reduction with the Paprifer System

The Paprifer process is a joint development of PPRIC and FERIC, and was devised to meet industry's need for a method of reducing the levels of bark, foliage, decay or grit in chip furnishes that would otherwise be undesirable in pulp and paper manufacture.

The method exploits the fact that most of these unwanted materials, readily weakened during the course of natural storage or by means of atmospheric steaming, can be broken down into small fragments through vigorous agitation in water, and then washed free of the wood chips through a perforated plate. A pilot plant has been in operation since December 1978. It is used regularly to demonstrate the method and to evaluate the processing characteristics of furnishes that would benefit from upgrading.

The furnishes produced in the Lumby chipping tests were deemed to be in need of upgrading and therefore, were the subject of trials with the Paprifer pilot plant. The objectives of the work were to characterize each of the four furnishes, to determine the upgrading characteristics of each furnish through trials with the Paprifer pilot plant and to generate upgraded chips for use in pulping trials.

Paprifer Inputs

Each of the four furnishes was screened into three fractions on a Williams Classifier before being shipped to PPRIC in Pointe Claire, Quebec (Table 3).

By way of simulating the handling practices of the pulp and paper industry, in which "fines" are usually screened from a furnish before it is used, Paprifer trials were confined to the "accepts" and "pins" fractions, blended together in their respective proportions.

The moisture content, basic density, and the size distribution of each blend were measured. The size distribution analysis entailed classifying a 3000-gm air-dried sample on a Williams Classifier, classifying each Williams fraction on a Domtar (thickness) Classifier, sorting each subfraction into its constituents, and then weighing the sorted constituents.

There were significant differences in moisture content between green and dry furnishes. The basic densities of three of the four furnishes are comparable to the values generally assumed for sound wood of these two species, while that of the air-dry hemlock is somewhat lower. Within each furnish, the size distribution of the wood and that of the bark were sufficiently similar to preclude the use of screening as a means of reducing the net bark content.

Paprifer Outputs

The prime purpose of the Paprifer trials was to establish the relationship between the bark content of a furnish at any stage during processing and the wood loss — sound and decayed — incurred in achieving it, although one of the objectives was to produce upgraded chips for use in pulping trials. Thus, to ensure that the relationship spanned a broad range of bark contents and wood losses, most of these trials were run longer than normal mill operating conditions would dictate. As a result, the upgraded furnishes that were provided for pulping trials possessed slightly lower-than-normal bark contents, obtained at the expense of higher-than-normal wood loss.

The overall results (Table 5) indicate that the use of larger holes in the extraction plate of the pulper favored a greater (and a more rapid) reduction in bark content. Also, the wood losses incurred in upgrading these furnishes were higher than those normally sustained in trials with eastern Canadian softwoods, possibly because these chips contained decay, or the rotor speed of the pulper may have been too high for western species and led to the breakdown of undue amounts of chips, and to their subsequent loss as Paprifer rejects. The four furnishes were quite dry, which may have resulted in brittle wood and refractory bark. The Paprifer process is designed for furnishes from small-diameter material with less bark. In all cases, percent recovery was close to 100, indicating only slight uncertainty in determining the disposition of wood and bark in these trials.

Upgraded Chips for Pulping Trials

The upgraded chips that were recovered from each of the seven trials were returned to Vancouver for future pulping. The properties and characteristics of these furnishes are listed in Table 6.

The moisture contents of the processed chips were high, but not any more variable than those of the non-upgraded material. Upgrading had little effect on basic density. Hence, little decay was removed or decay was not an important component of these furnishes. This uncertainty should be dispelled through separate pulping trials with upgraded and non-upgraded furnish. The size distribution of the chips, as reflected in both the Williams and the thickness classifications, was affected by treatment in the Paprifer plant. The percentages in the smaller-size fractions were higher, while those in the larger ones were smaller.

Green Mountain Barking and Chipping Tests

The Green Mountain trials were planned to test the concept of using a drum debarker for removal of bark and the inner rot from decadent hemlock and cedar having a thin outer shell and large core of decayed wood. In addition, chip and hog fuel samples were to be analyzed for their density, moisture content and energy value.

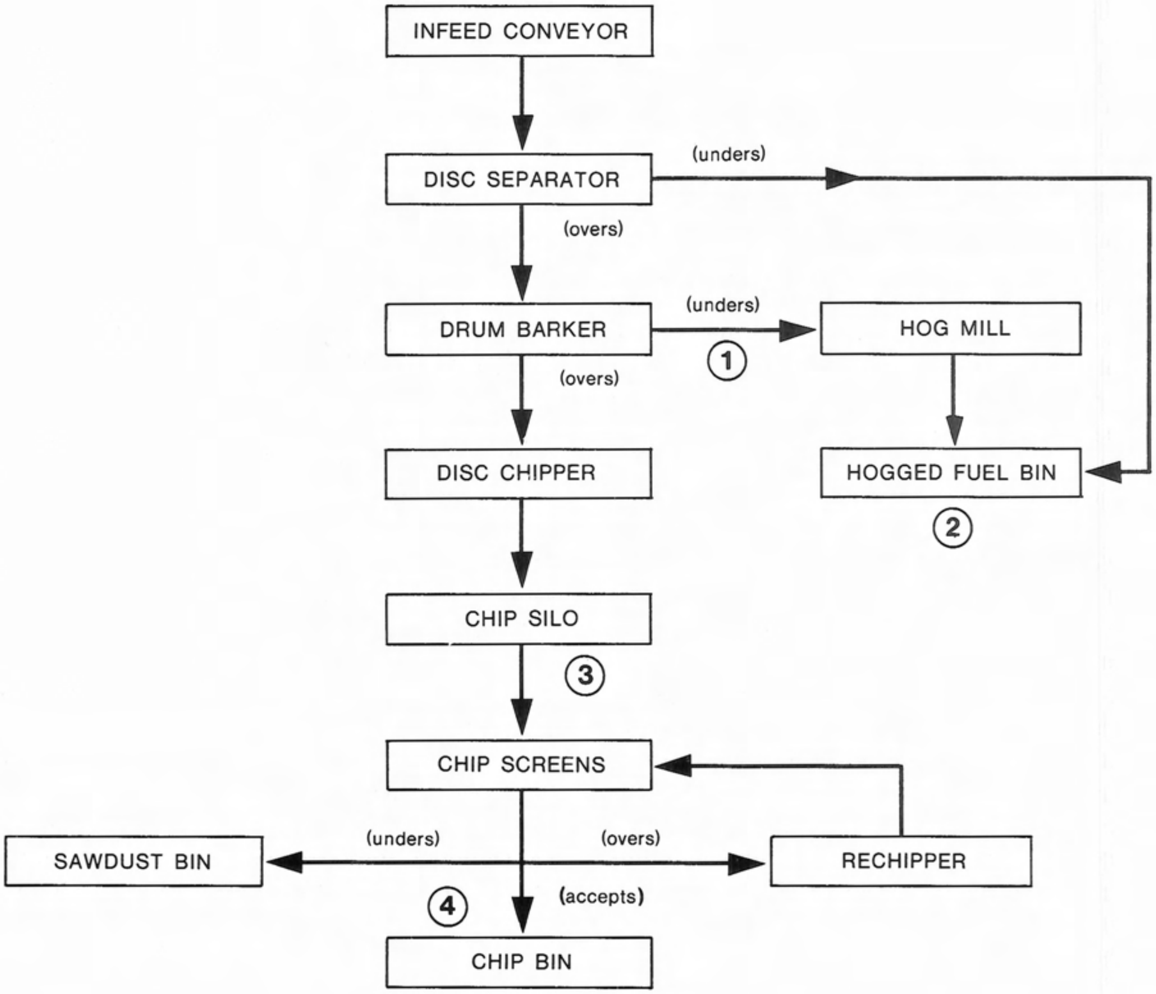
One truckload of material comprised of green, sheared hemlock and cedar approximately 1.5 m in length was shipped from Lumby, B.C. The truckload consisted of three separate boxes, each containing 15 m^3 and a total net weight of 14 560 kg. Hemlock and cedar were kept separate during the shearing, loading, debarking and chipping phases.

Equipment and Procedures

The following items of major equipment were used at the Green Mountain debarking and chipping trials (Fig. 4).

Disc Separator

The disc separator was a West Salem Model SD48-5 having 5 rolls with 90 mm between shafts, 95 mm between discs and 25.4 mm between the outer circumference of the disc and outer circumference of the shaft. The number of discs on each shaft from inlet to outlet of the separator were 7, 6, 7, 6, and 6. On shafts with 7 discs, the discs were flush with the walls. The disc separator was located at the entry to the drum debarker (Fig. 5).



(1) Sample point — Fibre content through Drum Barker slots

(2) Sample point — Hogged fuel fibre content, ash content, moisture content, BTU value

(3) Sample point — Chip analysis

(4) Sample point — Chip analysis.

Fig. 4. Material Flow and Sampling Points — Green Mountain

Fig. 5. West Salem Disc Separator

Drum Debarker

A Manitowac drum debarker having a diameter of 2.1 m, a length of 13.7 m and a rotation speed of 12 revolutions per minute was used for all tests (Fig. 6). It was necessary to use this machine, as the only drum debarker in British Columbia was not operative.

Chipper

A Nicholson Model L5 disc chipper with a 216.7-cm-diameter disc powered by a 597 kW electric motor capable of chipping a 61 cm maximum diameter log was used. The disc had 8 slots with 2 knives per slot ground at a 33-1/2 degree angle cutting against 2 anvils.

Chip Screens and Hog Mill

A Soderhamm Model KS1010 chip screen having round oversize holes 19 mm in diameter and round undersize holes 4.8 mm in diameter plus a Jefferey hammer hog mill were also utilized.

Analysis of Chip Output

Rot Content

Generally, the desired result of removing the inner rotten core during the debarking phase was not achieved (Tables 7, 8). This was mainly the result of shearing the material to a length of 1.5 m. We had been advised that the Nicholson L5 chipper would produce more size-acceptable chips with longer bolts with the preferred lengths in the 0.9 m to 1.8 m range. Also, debarking rates are faster with longer, heavier bolts. Consequently, we used longer bolts for the test. However, a shorter length would have resulted in more splitting and slabbing of the residues when they were sheared, and during drum debarking more heart rot would have been exposed. The percentage of rot in the hemlock chips substantiates this observation. Hemlock is less brittle than cedar and does not split as much when sheared. As Tables 7 and 8 show, the rot content of the hemlock chips is higher than that of the cedar chips.

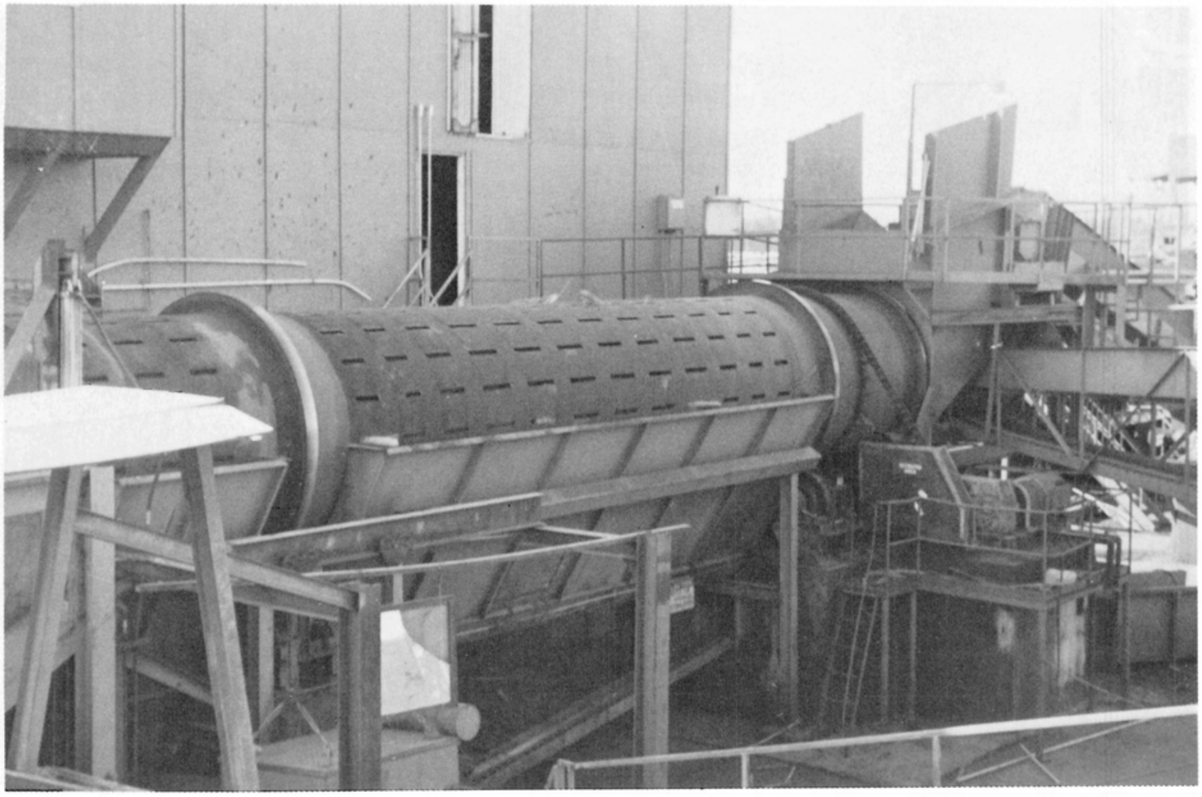


Fig. 6. Manitowac Drum Debarker

Bark Content

The percentage of bark in the hemlock chips after screening was quite acceptable after 63 minutes debarking time. However, the barker was not successful in removing the long stringy cedar bark until the bolts had been in the drum for 120 minutes (Table 8).

From the total chips, the acceptable chips averaged 80% for cedar after 60 minutes debarking and 72% for hemlock after 38 minutes debarking. For the hemlock, a longer barking duration resulted in greater shattering and a lower percentage of acceptable chips. The overall percentages of pulp chips and hog fuel produced by weight are given in Table 9.

Drum Debarker Waste

The material that passes through the slots in the drum debarker was sampled for analysis prior to hogging. Table 10 illustrates the percentages of material retained on a 9.6-mm screen after the bolts had been tumbled in the drum debarker for specified lengths of time. The optimum debarker time for hemlock occurred at approximately 60 minutes and for cedar at 90 minutes. After these lengths of time the amount of wood in the waste material begins to increase faster than the bark remaining on the bolts decreases.

Hogged Fuel

The waste material from the drum debarker and fines from the chip screens are conveyed to a hog mill where they were processed into hog fuel. Samples of the hog fuel were taken for analysis. The physical characteristics of the hog fuel are given in Table 11.

CONCLUSIONS

The problem of utilizing decadent cedar-hemlock in the B.C. Interior wet belt is of long standing. Utilization as hog fuel for energy has been suggested as one solution. Tests of a shear system to reduce transportation and processing problems prior to hogging of this material were carried out in 1982 and funded through the Canadian Forestry Service's ENFOR program. Material from these shear tests also provided an opportunity to test the feasibility of further upgrading such low-grade material to acceptable pulp chips.

Two tests were run, the first at Weyerhaeuser's Lumby, B.C. mill. In this case, bolts were chipped without barking, and the chips screened. Sixty percent of the chips were of an acceptable size; however, considerable rot remained after screening. Hence, the chips would not generally be commercially acceptable. Samples of the chips from the Lumby mill tests were also processed by the PPRIC/FERIC Paprifer process to remove bark and rot, and hence upgrade the chips to commercial quality. The conclusions resulting from the Paprifer trials are as follows:

1. Paprifer removed from one-half to two-thirds of the bark from each furnish — a satisfactory result considering the relatively high content of thick (refractory) bark in these chips.

2. As submitted, these furnishes may have contained substantial amounts of decay. A high level of decay would have been indicated by a significant change in basic density following processing. However, basic density was not affected by upgrading.

   No attempt was made to measure levels of decay either before or after upgrading. However, its effects will be discernible in the results of future comparative pulping trials with upgraded and non-upgraded furnish.

3. The upgraded chips were slightly smaller and more uniform than the non-upgraded ones.

4. The respective size distributions of the non-upgraded wood chips and of the bark contained in them were similar and offered no scope for upgrading through screening.

The second test was run at Weyerhaeuser's Green Mountain mill at Toutle, Washington. Bolts were debarked in a drum debarker, chipped, and the chips screened. Eight percent of the cedar chips and 72% of the hemlock chips were acceptable by size. Rot content remained high.

The results of these trials indicate that, though a high percentage of size-acceptable chips may be produced using sheared cedar-hemlock bolts, rot content in decadent stands remains a problem.

In choosing between the performance of drum debarking and Paprifer, drum debarking is the more effective of the two in achieving a low bark content, while Paprifer probably effects a greater reduction in levels of decay. Further, drum debarking is especially effective in processing relatively large-diameter material, while Paprifer is more suitably employed in upgrading chips produced from small-diameter stems. Studies aimed at exploiting these features of the two methods may be warranted.

Further work is required to develop a method to remove rot from the sheared bolts. One way may be to reduce the length of the sheared bolt so that more splitting during drum debarking might occur.

Given that acceptable quality chips can be produced, several further problems remain. The most serious of these is a chronic oversupply of chips (Sinclair 1984) in the area, resulting in low chip prices and little incentive to invest in chip upgrading facilities. In addition, there are no markets for pulp logs or hog fuel which are the other main products of the Interior decadent cedar-hemlock stands.

References

Berlyn, R., J. Hutchinson and R. Gooding. 1979. A Method for Upgrading Chips from Full Trees. Pulp and Paper Canada, Volume 80, No. 8, pp. 56-60.

Oakley, P. and G.H. Manning. 1984. An Analysis of Two Trials of a Portable Shear-Type Residue Processing System. Pacific Forest Research Centre, Victoria. BC-X-249.

Sinclair, A.W.J. 1984. The Economics of Utilizing Decadent Interior Cedar and Hemlock. FERIC Technical Report TR-59.

Table 1. Size distribution (%) of sheared residue (green basis)

Nominal Shearing Length (m)	100-200 cm	60-100 cm	30-60 cm	15-30 cm	15 cm	Total
0.6-0.8	3.5	80.8	8.0	2.3	5.4	100.0
0.8-1.0	36.0	46.6	10.2	2.9	4.3	100.0
1.0-1.2	76.6	10.9	3.0	1.9	7.6	100.0
1.2-1.4	82.1	7.0	4.3	2.0	4.6	100.0

Table 2. Analysis of chips — Lumby tests

	Green Hemlock		Dry Hemlock		Green Cedar		Dry Cedar	
	Before screens	After screens	Before screens	After screens	Before screens	After screens	Before screens	After screens
Bulk Density								
(kg/m^3) Wet	306.9	327.9	278.2	273.5	192.3	182.0	228.5	186.4
Dry	193.2	178.4	170.6	165.8	124.1	122.5	140.0	127.4
Moisture Content (% Wet Basis)	30.4	45.6	38.7	39.4	35.5	32.7	38.7	31.7
Chip Screening (%)								
Overs (>10 mm slots >45 mm holes)	3.3	2.1	3.2	3.7	7.3	11.1	4.1	8.0
Accepts (>7 mm)	63.6	64.3	49.3	59.6	52.9	62.6	62.1	59.6
Pins (>3 mm)	10.8	5.1	8.6	3.8	3.6	2.4	7.1	1.2
Fines (<3 mm)	5.1	0.3	6.5	0.5	3.5	0.5	4.5	0.2
Knots	—	0.5	1.5	1.2	0.2	—	1.3	1.4
Rot	6.5	15.6	25.8	27.2	14.0	8.1	17.2	28.1
Bark	10.7	12.2	5.1	4.0	18.5	15.3	3.7	1.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 3. Furnish Supplied for Paprifer Trials. Weights in kg (green basis)

Furnish	Accepts (>9.5 mm)	Pins (>7.48 mm) (<9.5 mm)	Fines (<4.8 mm)
Green Hemlock	41.60	9.38	4.46
Dry Hemlock	35.00	8.28	6.00
Green Cedar	34.04	4.36	2.40
Dry Cedar	26.66	5.50	3.14

Table 4. Characteristics of Each Furnish Before Upgrading

	Furnish			
	Green Hemlock	Dry Hemlock	Green Cedar	Dry Cedar
Moisture Content (% Wet Basis)	38.5	37.5	34.9	31.9
Basic Density	0.41	0.37	0.30	0.30
Bark Content (%)*	10.8	2.8	15.5	6.2

	Percentage Distribution							
Williams Class.	Wood	Bark	Wood	Bark	Wood	Bark	Wood	Bark
>29 mm	7.3	3.0	7.0	1.0	19.2	11.5	12.7	13.0
29-22 mm	9.3	6.1	11.3	1.6	13.7	11.5	12.8	7.8
22-16 mm	21.2	15.1	21.0	6.2	22.0	15.9	22.7	14.2
16-10 mm	36.6	35.7	36.4	36.4	29.8	32.2	33.0	25.3
10-4 mm	24.7	34.9	23.2	47.0	14.6	22.8	18.0	30.6
4-3 mm	0.3	1.7	0.4	1.6	0.2	0.7	0.4	1.5
<3 mm	0.6	3.5	0.7	6.2	0.5	5.4	0.4	7.6
Thickness Class								
>14 mm	2.9	0.2	2.0	0.1	7.5	0.3	4.1	0.2
14-12 mm	1.5	0.4	1.6	0.5	3.0	0.8	2.4	2.2
12-10 mm	1.5	1.0	2.7	0.5	3.5	4.2	2.4	4.5
10-8 mm	3.7	9.6	6.9	4.4	6.3	4.7	6.9	7.9
8-6 mm	7.9	16.7	12.5	9.1	12.5	15.7	12.8	6.6
6-4 mm	22.8	27.8	24.3	22.8	27.4	22.3	26.2	14.4
4-2 mm	37.5	24.5	32.9	36.4	25.4	23.9	29.7	27.1
<2 mm	22.2	19.8	17.1	26.2	14.4	28.1	15.5	37.1

* Bark Content = $\frac{\text{(Weight of Bark)} \times 100}{\text{(Wt. of Wood + Wt. of Bark)}}$

Table 5. Bark Content and Wood Loss as Affected by the Duration of Processing.

Furnish	Extraction Plate Perforations* (mm diameter)	Percent Recovery**		Duration of Processing (min) 0	4	8	12	15
Green — 1***	7.9	98.2	Bark Content %	10.8	7.9	6.3	5.3	4.7
Hemlock			Wood Loss %****	0	5.6	9.1	11.6	13.0
	11.1	100.5	Bark Content %	10.8	6.3	4.4	3.6	3.5
			Wood Loss %	0	5.6	11.1	15.6	17.1
Dry	7.9	100.0	Bark Content %	2.8	2.4	2.0	1.6	1.3
Hemlock			Wood Loss %	0	916	13.9	16.1	17.6
	12.7	101.7	Bark Content %	2.8	2.2	1.5		
			Wood Loss %	0	15.5	23.1		
Green	12.7	100.3	Bark Content %	15.5	11.1	7.8	5.6	4.5
Cedar			Wood Loss %	0	7.5	11.1	13.6	15.3 @ 16 min
Dry	12.7	99.	Bark Content %	6.2	—	—	1.9	
Cedar			Wood Loss %	0	—	—	22.2	
	12.7	100.4	Bark Content %	6.2	—	—	1.	
			Wood Loss	0	—	—	20.5 @	10 min

* The size of hole in the extraction plate determines the maximum size of fragment that can be rejected from the furnish in upgrading it.

** Percent recovery $= \frac{\text{(Weight of material recovered from trial)} \times 100}{\text{Weight of input furnish}}$

*** In each of the trials, the furnish was subjected to 30 minutes of atmospheric steaming immediately in advance of upgrading it.

**** Wood loss: the combined weight of sound and decayed wood lost in the rejects expressed as a percentage of the total weight of wood in the "accepts" and "rejects".

Table 6. Characteristics of the Upgraded Furnishes

	Furnish						
	Green Hemlock		Dry Hemlock		Green Cedar	Dry Cedar	
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7
Moisture Content (% Wet Basis	62.4	59.5	61.3	61.8	68.1	66.7	66.0
Basic Density	0.40	59.5	0.40	0.39	0.30	—	—
Bark Content (%)	4.7	3.5	1.3	1.5	4.5	1.9	1.9
	Percentage Distribution						
Williams Class. (excl. bark)							
>29 mm	1.6	2.1	3.6	3.4	5.5	3.8	5.9
29-22 mm	4.2	3.6	6.2	4.9	9.5	6.4	8.2
22-16 mm	12.4	13.5	15.9	16.6	25.4	19.0	19.2
16-10 mm	44.7	50.2	43.1	46.9	46.2	46.3	44.4
10-4 mm	36.3	29.9	30.0	27.2	13.1	24.0	21.6
4-3 mm	0.1	0.3	0.5	0.4	0	0.2	0.2
<3 mm	0.7	0.4	0.7	0.6	0.3	0.3	0.5
Thickness Class. (excl. bark)							
>14 mm	0.7	0.7	2.0	1.6	2.3	2.1	3.8
14-12 mm	0.4	0.6	0.6	0.7	1.9	1.4	1.1
12-10 mm	1.4	0.5	1.5	1.6	3.1	2.7	2.3
10-8 mm	2.3	3.4	3.1	3.0	6.3	3.8	4.3
8-6 mm	5.7	5.3	10.1	8.4	11.9	10.1	10.1
6-4 mm	17.7	19.7	23.5	26.5	30.3	26.0	24.4
4-2 mm	45.9	46.8	39.6	41.6	37.4	37.4	37.0
<2 mm	25.9	23.0	19.6	16.6	6.8	16.5	17.0

$$* \text{ Bark Content} = \frac{(\text{Weight of Bark}) \times 100}{(\text{Wt. of Wood} + \text{Wt. of Bark})}$$

Table 7. Analysis of Hemlock Chips - Green Mountain.

	Debarking Time					
	38 Minutes		63 Minutes		83 Minutes	
	Before Screens	After Screens	Before Screens	After Screens	Before Screens	After Screens
Bulk Density						
(kg/m^3) Wet	230.4	230.1	219.4	219.0	216.3	207.7
Dry	143.6	142.5	139.6	134.3	131.7	129.8
Moisture Content						
(% Wet Basis)	37.7	38.1	36.4	38.7	39.1	37.5
	Percentage Distribution					
Chip Screening (%)						
Overs (>10 mm slots >45 mm holes)	3.3	0.8	2.5	0.9	12.5	2.9
Accepts (>7 mm)	71.1	71.8	64.8	56.2	56.4	63.8
Pins (>3 mm)	2.2	2.3	3.3	4.6	4.3	3.3
Fines (<3 mm)	0.3	0.3	0.6	0.2	0.5	0.2
Knots	3.2	0.3	1.0	4.6	1.5	2.9
Rot	18.1	24.0	27.3	33.3	24.2	26.8
Bark	1.9	0.6	0.5	0.3	0.6	0.1
Total	100.1	100.1	100.1	100.1	100.0	100.0

Table 8. Analysis of Cedar Chips — Green Mountain

	Debarking Time					
	60 Minutes		90 Minutes		120 Minutes	
	Before Screens	After Screens	Before Screens	After Screens	Before Screens	After Screens
Bulk Density						
(kg/m^3) Wet	158.1	156.5	153.1	158.0	160.9	154.8
Dry	104.6	106.6	104.2	105.5	107.0	104.2
Moisture Content						
(% Wet Basis)	33.8	31.9	31.9	33.2	33.5	32.7
	Percentage Distribution					
Chip Screening (%)						
Overs (>10 mm slots >45 mm holes)	6.9	3.4	4.2	1.6	3.5	2.1
Accepts (>7 mm)	71.2	79.4	81.8	80.7	82.4	88.2
Pins (>3 mm)	3.4	2.2	2.5	3.3	3.0	2.1
Fines (<3 mm)	0.7	0.2	0.5	0.2	0.3	0.2
Knots	2.9	3.4	2.0	2.0	2.1	0.8
Rot	9.9	7.9	6.8	10.0	7.8	6.0
Bark	5.1	3.5	2.3	2.3	0.9	0.7
Total	100.0	100.0	100.1	100.1	100.0	100.1

Table 9. Weight of Chips and Hogged Fuel Produced

	Weight (Green Basis) kg	%
Hemlock Pulp Chips	4990	53.9
Hemlock Hogged Fuel	4264	46.1
Total	9254	100.0
Cedar Pulp Chips	1558	42.7
Cedar Hogged Fuel	2132	57.3
Total	3720	100.0
Grand Total Weight of Chips and Hogged Fuel		12 974 kg
Weight of Wood as Weighed at Lumby and Shipped to Green Mountain		14 561 kg

Table 10. Analysis of Debarker Waste from Green Mountain

Species	Debarking Time (mins.)	Retained on 9.5 mm Diameter Screen (%) Wood	Bark, Dirt etc.	Amount in Pan (%)	Total (%)
Hemlock					
	23	38.3	43.1	18.6	100.0
	43	46.3	37.1	16.1	100.0
	58	69.8	21.3	8.9	100.0
	78	87.5	4.3	8.2	100.0
Cedar					
	15	43.4	44.8	11.8	100.0
	30	61.3	34.0	4.7	100.0
	45	47.9	43.8	8.3	100.0
	65	51.3	42.1	6.6	100.0
	90	73.6	17.7	8.7	100.0
	120	83.9	10.5	5.6	100.0

Table 11. Analysis of Hogged Fuel from Green Mountain

	Weight Distribution Percent Retained						Moisture Content (% Wet Basis)
Species	45 mm	29 mm	16 mm	9.5 mm	4.8 mm	< 4.7 mm	
Cedar	40.0	8.6	12.0	10.5	12.2	16.7	47.8
Hemlock	9.9	9.0	20.1	21.1	20.4	19.4	41.9

Laboratory Analysis

	Califoric Value kj/kg o.d.	Ash Content % Dry Basis
Cedar Hog Fuel	20 838	4.92
Hemlock	19 213	7.83