SLICING STUDY OF PRUNED PINUS RADIATA LOGS

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ABSTRACT

A conversion study carried out at a veneer slicing plant involved the slicing of 23 bolts of pruned **Pinus radiata** D. Don. The slicing operation produced several size categories of three grades of clear veneer and one grade of knotty veneer. Three slicing strategies were used. Over-all veneer conversion peaked in the middle size range and fell rapidly as small-end diameters dropped below 425 mm.

Keywords: sliced veneer; veneer; **Pinus radiata**.

INTRODUCTION

A study carried out with pruned *Pinus radiata* logs in NZ Veneers Ltd's slicing plant at Christchurch provided the opportunity to observe and document each of the component operations in the slicing process, and to quantify the conversion of pruned *P. radiata* logs at each of these component operations.

Logs were selected from Cpt 28 in Kaingaroa State Forest and transported via road and coastal shipping to Christchurch. This log source was chosen as the stand contained pruned logs with a wide range of diameters and previous sawmill studies had provided information on log internal properties. It was considered desirable to observe the slicing operation on a range of sizes as well as a range of log qualities and without the added complication of high resin pocket numbers. Park (1980, 1986) studied logs from Cpt 28 and observed low to moderate resin pocket numbers and small knotty cores in bottom bolts (0–2.7 m) and relatively large knotty cores in second bolts (2.7–5.4 m).

NZ Veneers Ltd's plant incorporates a sawmill and this allows additional flexibility in the slicing approach. Bolts with small-end diameters in excess of 700 mm are slabbed and sectioned into flitches prior to either crown- or quarter-slicing; those with small-end diameters up to 700 mm are slabbed before crown-slicing.

The component operations of the slicing process, the slicing of pruned *P. radiata,* and the resulting produce have been described elsewhere (Somerville & Gosnell in press). A description of the study itself and the quantitative results are presented here.

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METHODS

The shipping container used to transport logs allowed a total sample of 12 5.4-m logs (24 2.7-m bolts). It was decided to both measure and photograph a large portion of the veneer as it was produced. To keep the work to a practicable level the log sample was divided into two sub-samples with an intensive analysis restricted to one of these.

Sample I contained Logs 1–7 (14 bolts) and covered the s.e.d. range 387–772 mm. These bolts were assessed in the field and then again for conversion and product description at each of the following operations: sawing, slicing, drying, clipping and book making, and grading. Veneer was photographed after slicing. The five Sample II logs (Logs 8–12) were assessed initially in the field and finally in the dried and clipped book stage and served to provide additional over-all grade and conversion results.

Log Assessment

The Cpt 28 stand was naturally regenerated with a nominal establishment year of 1941. Butt logs were pruned in three lifts at ages 6, 9, and 18 years. Thinnings took place at ages 6, 9, 18, and 21 years, reducing stocking to around 150 stems/ha. Since final thinning the stocking had been further depleted by extraction of selected stems for a series of mill studies.

Sample trees were selected as being visually straight, symmetrical, free from damage, and able to yield pruned peeler bolts across the s.e.d. range 350–800 mm. Trees were felled and the pruned butts cross-cut at 5.4 m. On the ends of Sample I logs, geometric centres and X and Y axes were drawn (these markings were added to freshly exposed bolt ends when logs were cross-cut at the mill). Holes drilled along these axes at set distances ensured their permanence and also provided fixed reference points. Having axes marked on logs allowed the eventual reconstruction of both internal and external log characteristics in three-dimensional co-ordinates. Both Sample I and Sample II logs were then sectionally measured to provide accurate underbark volumes and dimension parameters.

Sawmilling Sample I and II Logs

Each 5.4-m log was cut into two 2.7-m bolts at the mill. These were sawn in the mill in one of two patterns (Fig. 1). Bolts greater than 700 mm s.e.d. were ripped in the intricate pattern depicted in Fig. 1(a), the net result being four flitches each with an approximately hexagonal cross-section. Bolts of 700 mm s.e.d. or less were slabbed on four sides leaving adjacent flat surfaces at approximately right angles (Fig. 1(b) (c)).

For Sample I bolts and flitches the cross-sectional profiles and X and Y axes of each end were measured, mapped, and drawn. Corresponding measurements were also made at bolt and flitch midpoints.

Slicing Sample I

After heating (around 48 h at 80°C), bolts and flitches were sliced into 0.6-mm veneer. Slices from sawn faces were rejected until clear merchantable dimensions were obtained. All subsequent veneer was identified with an elaborate coding system recording

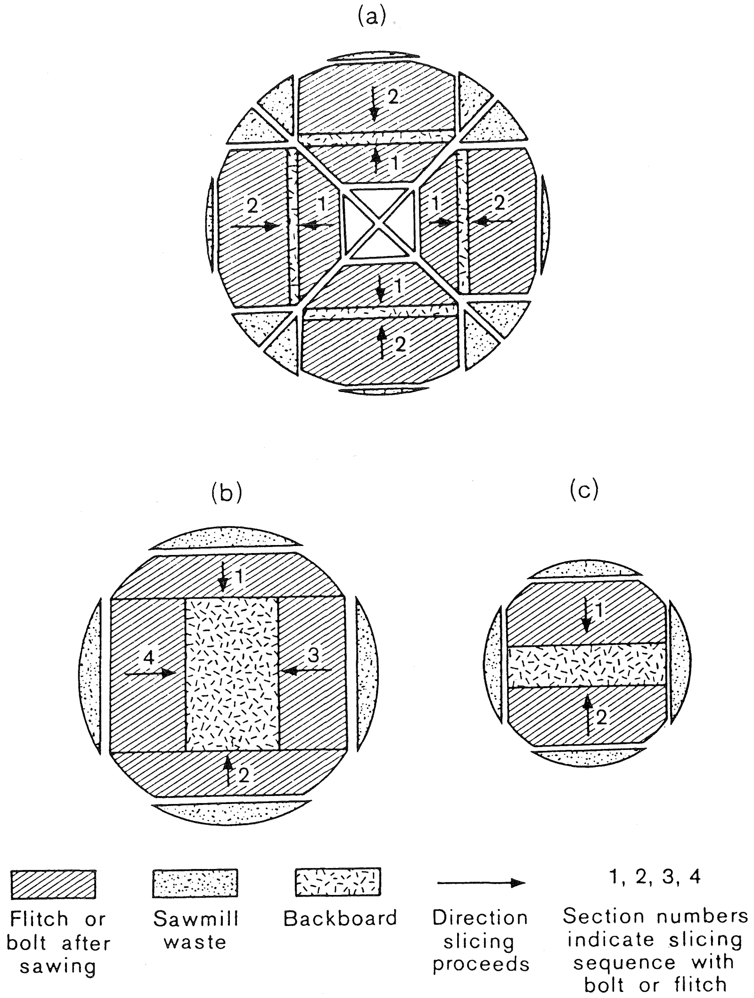

FIG. 1—Cross-sections of bolts showing sawing pattern, sawing waste, slicing sequence, and backboards. (a) Bolts greater than 700 m s.e.d. (b) Bolts greater than 450 mm and up to 700 mm s.e.d. (c) Bolts up to 450 mm s.e.d.

log number, bolt number, flitch number, section number (*see* Fig 1), veneer sheet number, and whether veneer was considered clear, knotty, or reject. This code was chalked on outermost sheets whenever a change in classification occurred. In addition, every tenth sheet of veneer was numbered and then length, maximum width, and minimum width, on all numbered sheets were measured.

Approximately every fifth sheet of veneer was photographed on a light table. This provided a permanent record of the study and, after scale was computed, allowed subsequent mapping and measurement of internal log features. Bundles of 32 sheets were measured for thickness using specially designed compression calipers. All veneer was replaced in the sequence in which it was sliced and this sequence was maintained throughout the whole veneer-making process. Reject veneer was dumped at this point.

Drying Sample I

The drying schedule was designed to reduce moisture content to around 12%. After drying, veneer was separated into bundles of 32 sheets (or part bundles where less than 32 sheets remained in a section). Each bundle retained the slicing sequence and contained only sheets from a single section. A sample of lengths and widths was remeasured in order to determine longitudinal and tangential shrinkage.

Clipping Samples I and II

Both sides of each bundle were scrutinised to decide on its acceptability and the best clipping strategy to maximise usable veneer. On occasion outer sheets were rejected. With clear veneer, if inner sheets were rejected then the bundle was split at this point so that continuous veneer sequence was maintained. Clipping widths were anything in excess of 120 mm; however, clipping lengths were confined to 252–248 cm, 221–217 cm, 192–188 cm, and 160–155 cm, with 252–248 cm being the standard length. Acceptable bundles were end- and edge-clipped (adjacent edges at right angles) and tied. Bundles were now termed "books" and sheets "leaves".

All books were identified by code and number. They were then measured for length, width, and thickness using the compression calipers. This allowed volumes of usable veneer as well as radial shrinkage to be calculated.

Grading Samples I and II

All books were again scrutinised and acceptable ones were graded into export, local, backing, and acceptable knotty (for description of grades *see* Somerville & Gosnell in press). Veneer grades were recorded against book code and number.

RESULTS

Parameters of the logs and bolts are given in Table 1. Branch stub and occlusion measurements were obtained after reconstructing the internal features of bolts using both the photographic record and the slicing sequence. Although the knotty cores of A bolts were smaller than B bolts they were not as small as hoped for (with the exception of Bolts 2A and 6A).

Bolts were milled and sliced according to the patterns shown in Fig. 1 as follows:

Pattern (a) – 1A, 1B, 2A, and 2B
Pattern (b) – 3A, 3B, 4A, 4B, 5A, 5B, 6A, 6B, 8A, 8B, 9A, and 9B
Pattern (c) – 7A, 7B, 10A, 10B, 11A, 11B, and 12A.

Bolt 12B of Sample II was mostly reject and this bolt was deleted from the study.

Main Operation Centres

Sawmill

Bolts sawn on Pattern (a) had by far the lowest sawmill conversions (Table 2 and Fig. 2). This was partly attributable to the large amount of sawing but was due mostly to the waste (Table 3) caused by sawing hexagonal flitch cross-sections (*see* Fig. 1). The innermost wedges of waste were formed in the low-grade log centre. However, the outer wedges contained potentially valuable material. These were lost because of

TABLE 1—Log and bolt descriptive parameters

	Butt log (0–5.4 m)		Bolt A (0–2.7 m)					Bolt B (2.7–5.4 m)				
	No.	dbh (mm)	s.e.d.u.b. (mm)	Volume u.b. (m^3)	DOS (mm)	DOO (mm)	KC (mm)	s.e.d.u.b. (mm)	Volume u.b. (m^3)	DOS (mm)	DOO (mm)	KC (mm)
Sample I	1	912	772	1.446	418	498	500	746	1.232	430	515	515
	2	863	718	1.228			225*	700	1.088	368	418	422
	3	655	550	0.717	315	348	368	514	0.620	355*	400*	425*
	4	625	542	0.714	220*	335*	350*	510	0.588	340*	400*	400*
	5	607	507	0.591	325*	370*	370*	486	0.540	280*	375*	375*
	6	598	524	0.638	200*	240*	250*	482	0.535	325*	395*	395*
	7	498	400	0.377	315*	350*	375*	387	0.339	280*	315*	350*
	Mean				299	357	348			340	403	412
Sample II	8	673	583	0.824				559	0.693			
	9	590	526	0.647				482	0.554			
	10	561	448	0.501				438	0.405			
	11	490	413	0.431				388	0.342			
	12	447	407	0.387								

s.e.d.u.b.	Small-end diameter under bark
Volume u.b.	Volume under bark
DOS	Diameter over branch stubs
DOO	Diameter over occlusion scars
KC	Knotty core
*	Measured in only one place as branches remained concealed in the backboard (Log 2 Bolt A had occlusion scars visible in only one plane).

TABLE 2—Number of bolts, bolt volumes, and conversions (with standard deviations in parentheses) at main operation centres

	Pattern	No. bolts	Mean bolt volume (m³)	Conversions as a percentage of bolt volume				
				Sawmill (%)	Slicer (%)	Dryer (%)	Clipper (%)	Grading (%)
Sample I	a	4	1.248 (0.148)	76.9 (2.2)	57.4 (7.2)	52.5 (6.4)	37.1 (5.8)	36.2 (6.3)
	b	8	0.618 (0.070)	92.1 (2.5)	68.6 (10.7)	63.2 (9.7)	43.9 (7.9)	41.2 (9.4)
	c	2	0.358 (0.027)	89.4 (0.0)	44.7 (3.5)	42.8 (3.2)	17.9 (0.1)	12.3 (4.2)
Sample I mean		14	0.761 (0.344)	87.4 (7.3)	62.0 (12.4)	57.2 (11.0)	38.2 (11.2)	35.6 (12.7)
Sample II*	b	4	0.680 (0.112)					35.4 (5.7)
	c	5	0.413 (0.059)					28.7 (7.8)
Samples I plus II	a	4	1.248 (0.148)					36.2 (6.3)
	b	12	0.638 (0.086)					39.3 (8.6)
	c	7	0.397 (0.056)					24.0 (10.4)
Over-all mean		23	0.671 (0.304)					34.1 (10.9)

* Conversion was followed through only for bolts in Sample I.

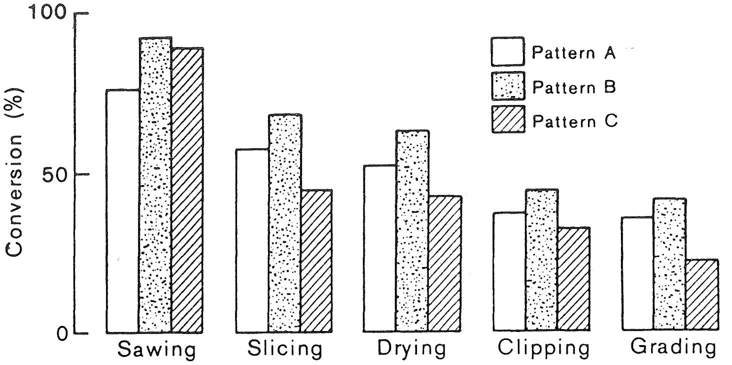

FIG. 2—Percentage of bolt volume remaining (conversion %) after each operation.

TABLE 3—Waste as a percentage of bolt volume at main operation centres. Sample I bolts

	Pattern		
	(a)	(b)	(c)
No. bolts	4	8	2
Mean bolt volume (m³)	1.248	0.618	0.358
Sawmill - slab and sawdust (%)	23.1	8.9	10.6
Slicer -			
Backboard (%)	7.2	12.5	24.0
Reject occl. (%)	6.5	8.0	19.8
Reject face (%)	5.8	2.0	0.9
Dryer - shrinkage (%)	4.9	5.4	1.9
Chipper - reject and clip (%)	15.4	19.3	24.9
Grading - reject and size (%)	0.9	2.7	5.6

Reject occl. = reject veneer associated with the occlusion zone.
Reject face = reject veneer from the outer surfaces of flitches.

the need to cut three of the flitch sides at right angles (*see* Somerville & Gosnell in press). Patterns (b) and (c) only involved slabbing bolts to produce four adjacent sides at right angles.

Slicer

Measurements of 41 bundles of 32 sheets gave an average green veneer thickness of 0.63 mm (standard deviation 0.01 mm). Losses at the slicer were least for Pattern (a) and greatest for Pattern (c) (Table 2 and Fig. 2). These differences were associated mainly with backboard dimensions and width of the occlusion zone (Tables 3 and 4).

TABLE 4—Sample I bolts backboard widths and thicknesses

Sawing pattern	Mean s.e.d.u.b. (mm)	Backboards		
		No.	Mean width (mm)	Mean thickness (mm)
a	734	16	361	23
b	514	8	311	90
c	393	2	390	86

Sawing Pattern (a) tends to small backboards; however, in the study these occurred either in the occlusion zone or in the clear zone. Backboards in Pattern (c) extended through the bolt cross-section, incorporated clearwood, and were proportionally large. Pattern (b) backboards were mostly confined to low-grade log centres. Knotty cores in Pattern (c) bolts were proportionally greater than in larger bolts and so consequently were the veneer losses associated with the occlusion zone. Since slicing proceeded from two faces in each of the four flitches per bolt in Pattern (a) material, losses associated with rough surface veneer were higher than in other patterns.

Dryer

Drying was designed to achieve a final moisture content of around 12%. Knotty veneer, having a lower moisture content than sap, was dried separately at lower temperature. A sample of numbered sheets was remeasured (previously measured green) for length and width after drying. Book thickness was measured and number of sheets recorded in order to calculate average veneer thickness and dry veneer volume.

Longitudinal shrinkage was practically insignificant; radial shrinkage was small and has no adverse effect with crown slicing. Tangential shrinkage was greater than in other planes (Table 5).

TABLE 5—Shrinkage in clear and knotty veneer (standard deviations in parentheses)

	Radial (%)	Tangential		Longitudinal		Volume (%)
		N	%	N	%	
Knotty	0.48	28	2.31 (1.84)	10	0.08 (0.10)	2.94*
Clear	2.22	51	5.32 (1.29)	20	0.20 (0.11)	7.78†

N Number of observations.
* Based on an average green knotty sheet of 2.7 m × 0.3 m × 0.63 mm.
† Based on an average green clear sheet of 2.7 m × 0.375 m × 0.63 mm.

Clipper

Of the 9832 clear veneer sheets of Sample I reaching the clipper, 107 were rejected. These were mostly outermost veneer slices that would be less than 120 mm wide when clipped. Of the 2529 knotty sheets, 11 books containing 331 sheets were rejected primarily on the grounds of unacceptable bark-encased knots. The mean veneer losses per bolt in Table 3 include both reject and clipping losses. However, reject losses were small – of the order of 1–2% of round log volume in each of the slicing patterns. The differences between patterns primarily reflect scale, i.e., larger bolts result in larger veneer sheets and less reduction from clipping.

Grading

Losses at the grading operation centre (Table 3) were due largely to further rejection of knotty veneer (there was no rejection of clear veneer). There was little difference between total veneer volumes computed using either nominal saleable book length or true measured book length.

Veneer grades and grain configuration have been described elsewhere (Somerville & Gosnell in press). Grain configuration is paramount in determining clear veneer grade. A "cathedral grain" pattern, usually an essential prerequisite for export grade (the top grade), was mostly absent in Sample I veneer. This appeared to be because of the wide growth rings and nodal swelling, coupled with the orientation of the slice with regard to the axis of the log. Several Sample II bolts yielded export veneer (Table 6). The bulk of acceptable veneer fell in the local grades, i.e., clear veneer suited to making face layons. The yield of knotty veneer was generally low – a reflection of the high incidence of unacceptable bark-encased knots.

Resin Pockets

Clear zone resin pocket incidence was generally low (Table 7) and in only one book was veneer loss due solely to resin pockets. (Resin pockets were sometimes present on waste from books clipped for reasons other than resin pockets). The occlusion zone included a significant number of resin pockets; however, this zone was rejected because of the occlusion scars. The highest incidences occurred in the knotty zone. Here, as in the other zones, the small Type 3's dominated and, as in the clear zone, clipping and rejecting were carried out for reasons other than resin pockets. It must be pointed out that the study finished at the dried, clipped, graded book stage and resin pockets could have caused clipping and reject losses at the layup stage.

Resin pockets can be very important in sliced veneer manufacture – we have seen batches of clear veneer in which more than half the output was rejected because of them.

Conversion Trends

Conversion trends must be viewed with caution since the study samples were small and results would have been peculiar to the study logs, mill, veneer-making procedures, and market constraints operating at the time.

Bottom bolts converted slightly better than second bolts (35.7% compared to 32.3% over-all). However, it was not possible to conclude whether this was a function of any

TABLE 6—Percentage of total saleable veneer in each veneer grade, by sample and by slicing pattern

Sample	Pattern	No. of bolts	Mean bolt volume (m^3)	Mean saleable veneer (m/m^3)	Conversion (%)*	Saleable veneer (%)									
						Clear							Knotty		
						Export 8†	Local 8	Local 6†	Local 5†	Backing 8	Backing 6	Total clear	Knotty 8	Knotty 6	Total knotty
I	a	4	1.248	0.451	36.2	0	84.0	0.4	0.1	7.1	2.7	94.3	5.0	0.7	5.7
	b	8	0.618	0.257	41.2	0	51.1	8.2	1.4	15.6	7.7	84.0	14.6	1.4	16.0
	c	2	0.358	0.044	12.3	0	16.1	0	6.9	0	0	23.0	37.9	39.1	77.0
Mean		14	0.761	0.271	35.6	0	65.5	4.4	0.9	11.4	5.2	87.4	10.7	1.9	12.6
II	b	4	0.680	0.239	35.4	46.9	23.2	2.7	3.4	3.9	2.4	82.5	17.5	0	17.5
	c	5	0.413	0.121	28.7	6.5	16.9	14.1	0.8	6.3	9.4	54.0	44.3	1.7	46.0
Mean		9	0.532	0.173	31.6	31.3	20.8	7.1	2.4	4.8	5.1	71.5	27.8	0.7	28.5
I plus	a	4	1.248	0.451	36.2	0	84.0	0.4	0.1	7.1	2.7	94.3	5.0	0.7	5.7
II	b	12	0.638	0.251	39.3	14.9	42.2	6.5	2.1	11.9	5.9	83.5	15.5	1.0	16.5
	c	7	0.397	0.095	24.0	5.7	16.8	12.3	1.6	5.5	8.3	50.2	43.6	6.2	49.8
Over-all mean		23	0.671	0.229	34.1	8.9	52.7	5.2	1.4	9.5	5.1	82.8	15.6	1.6	17.2

* Arithmetic means of individual bolt conversions.

† 5, 6, and 8 denote veneer book length in feet (the units commonly dealt with in trading).

TABLE 7—Weighted mean resin pocket incidence (Sample I)

		No. of resin pockets/m^2 veneer surface			
		Type 1*	Type 2	Type 3	All resin pockets
All bolts	Clear zone	0.028	0.039	0.140	0.207
All bolts	Knotty zone	0.080	0.101	0.628†	0.809
All bolts	Occlusion zone	0.234	0.158	0.353†	0.745
A bolts	All zones	0.054	0.049	0.228†	0.331
B bolts	All zones	0.070	0.082	0.258†	0.410
All bolts	All zones	0.061	0.064	0.241†	0.366

* For a description of resin pocket types, see Somerville (1980).

† Incidence of Type 3 resin pockets in the occlusion zone in Bolt 4A and in the knotty zones in Bolts 7A and 7B is not included because of confusion with bands of damaged resin canals.

or all of the following: bolt size, bolt shape, branch size, branch quality, and knotty core size.

Total veneer conversion (in dried clipped books) was plotted on bolt small-end diameter for the 23 bolts of Samples I and II (Fig. 3). There was a sharp rise in conversion through the critical s.e.d. range 350–450 mm. Pattern (b) bolts displayed a wide range in results while three of the four bolts sliced on Pattern (a) converted quite poorly.

Clear veneer conversion was plotted against clearwood sheath (s.e.d. – knotty core, Table 1) for Sample I bolts (Fig. 4). As might be expected, a relationship between clear conversion and clearwood sheath was apparent. However, this was partly confused by clear veneer production from within the knotty core resulting after edge- and end-clipping of defects, particularly where bolts and knotty cores were large and branches were few. Pattern (c) bolts were handicapped by both small size and small clearwood sheaths and yielded minimal clears. Results for Pattern (b) varied but generally displayed increasing clear conversion with increasing clearwood sheath. Three of the four Pattern (a) bolts had lower clear conversions than Pattern (b) bolts with corresponding clearwood sheaths. This may be a reflection of the additional losses of clear outerwood at the sawmill and again as backboards at the slicer.

Knotty veneer contributed 17.2% of the total veneer produced, but acceptability of knotty veneer depends very much on knot quality. Many intergrown knots of less than 60 mm diameter are preferred. Branch stubs in the study logs tended to be bark encased over part of their length and consequently much of the potentially acceptable knotty veneer was rejected (a consequence of high initial stockings and late pruning). Had branch stubs been mostly intergrown then over-all bolt conversions would have been higher.

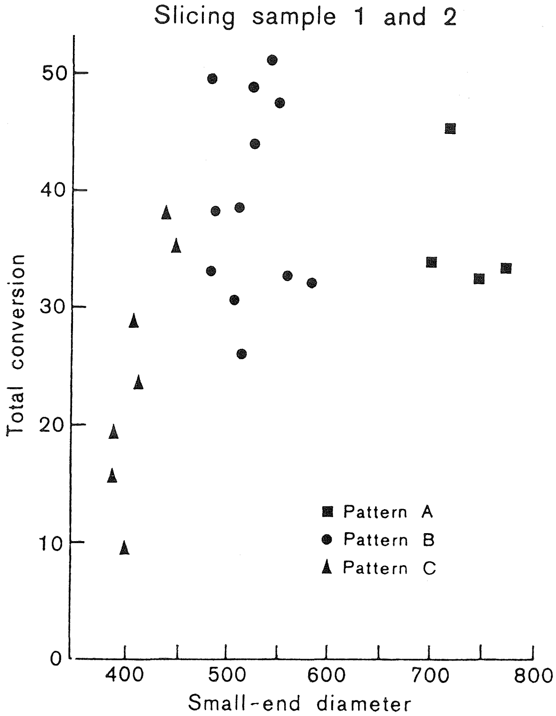

FIG. 3—Total conversion (volume of total veneer/bolt volume × 100) on small-end diameter. Sample I and II bolts.

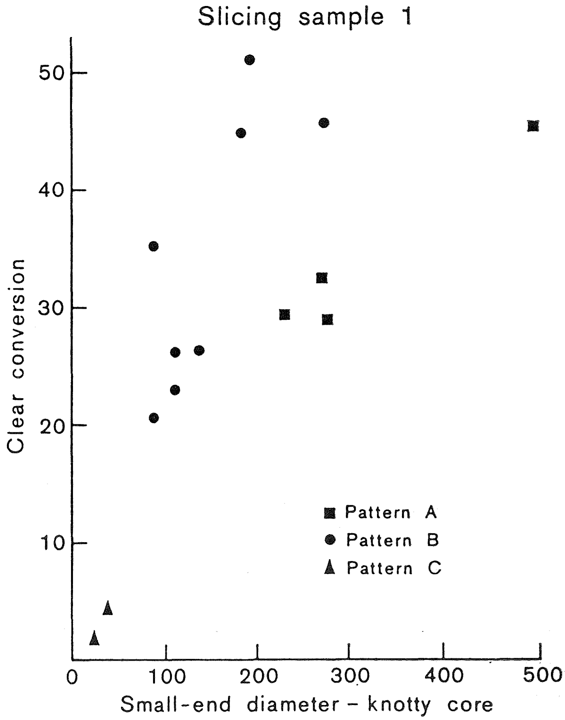

FIG. 4—Clear conversion (volume of clear veneer/bolt volume × 100) on small-end diameter minus knotty core. Sample I bolts.

DISCUSSION

The study bolts were of good external appearance and quite satisfactorily covered the diameter range normally encountered when slicing *P. radiata.* In terms of internal properties, the knotty cores of some of the bolts were larger than anticipated. Core sizes over-all could be rated as being in the poor to medium range. Resin pockets were present in low numbers and had practically no effect on the production of dried and clipped veneer. They may have had an effect at the "layup" stage; however, this was beyond the scope of the study.

The existence and definition of veneer grades are to a degree dictated by current consumer preference. "Cathedral grain" is the main grain configuration sought in the top clear veneer grade. The combination of wide growth rings, large nodal swellings, and the orientation of the slice with regard to the bolt axis meant very little of this grain figuring was produced.

A particular veneer quality is recovered only in response to its marketability. Conversion depends on market factors as well as wood properties and plant factors. The present high demand for knotty veneer means veneer with particular knot characteristics is actively sought when previously knotty cores were not sliced.

Bolt size is an important consideration. Conversions fell sharply with bolt small-end diameters of below 425 mm. Crown-slicing from four sides resulted in the highest conversions with conversion roughly increasing with bolt diameter and clear veneer conversion generally increasing with clearwood sheath thickness. Pursuing the strategy of quartering large bolts and crown-slicing the flitches appeared to sacrifice both conversion and clear veneer yield. This strategy does, however, provide the option of either crown- or quarter-slicing flitches and also of reducing very large bolts to more manageable dimensions.

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REFERENCES

PARK, J. C. 1980: A Grade Index for pruned butt logs. **New Zealand Journal of Forestry Science 10:** 419–38.

——— 1986: Peeled veneer yields from pruned radiata pine. Paper presented at Conversion Planning Conference, Rotorua, 8–11 April.

SOMERVILLE, A. 1980: Resin pockets and related defects of **Pinus radiata** grown in New Zealand. **New Zealand Journal of Forestry Science 10:** 439–44.

SOMERVILLE, A.; GOSNELL, T. K. Slicing pruned radiata pine in a New Zealand mill. **FRI Bulletin** (in press).