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IN-WOODS CHIP PRODUCTION AT A CENTRAL LANDING

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ABSTRACT

The Forest King integral chain flail debarker and disc chipper was observed operating at a central landing. Partially delimbed radiata pine pulpwood from an 18 year old clearfell operation was trucked to the site for processing. Daily production was increased by 11% through operating in this manner, compared to the mobile operation working from "cold-decked" wood on several landings. Chip quality and bark content results were also compared.

In addition, productivity, chip quality and fibre recovery measurements were made on four age/stem treatments; 18 year old pulpwood, 18 year old full trees, 28 year old pulpwood, and 8 year old full trees. Fibre recovery ranged from 77% to 92%, while productivity ranged from 0.2 to 1.0 tonnes per productive minute.

INTRODUCTION

The development of the New Zealand-designed and built Forest King 2318 flail debarker-chipper has been previously reported (Franklin, 1991). The unit features a double-drum chain flail, to delimb and debark stems up to 58 cm (23") diameter, and a 46 cm (18")capacity Morbark disc chipper. The chipper is powered by a 450 kW diesel engine, while a separate 180 kW engine drives the hydraulic motors for the flail drums, the conveyors and the hydraulic cylinders for the stabilisers. Logs are fed into the unit using a Komatsu PC150-LC knuckleboom loader.

Figure 1 - Forest King 2318 working in Omataroa Forest

The Forest King was first set up as a mobile unit in a 14 year old radiata thinnings operation where frequent moves between landings were required. In February 1991, the machine was moved to a clearfell logging operation on a "semi-permanent" central landing in Omataroa Forest where wood was delivered to the unit by logging truck.

This Report examines the system of operation for in-woods chip production at the central landing and compares it with the mobile operation. A second objective of this report is to assess the capability of the Forest King flail-chipper in handling full tree radiata pine.

The fibre recovery (chip output versus roundwood input) of four age/stem treatments is discussed; partially delimbed 18 year old radiata clearfell, full tree (untrimmed and untopped) trees from the same operation, 28 year old pulplogs from a separate clearfell operation, and full tree material from an 8 year old pre-commercial or "waste" thinning operation.

Delimbing capacity, quality of chips produced, and the volume of debris generated from these various trials is also discussed.

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STUDY AREA

At Omataroa Forest, the Forest King was required to delimb, debark and chip pulpwood from several clearfell and thinning operations. Approximately half of the volume processed was extracted by cable system, with the remainder extracted by skidders. The terrain restricted the landing size, resulting in insufficient space to operate the cable hauler, delimb, process, sort and stack logs, and load trucks, as well as run a flail-chipping operation.

To overcome this limitation, a large landing was prepared centrally in the forest. Sawlogs, export logs and oversize pulp logs were sorted at the hauler and skidder landings, and the pulpwood was carted, by conventional logging trucks, a distance of four to nine kilometres to this central landing, or "satellite" chipping operation.

The landing was not a merchandising yard, rather a central place where the delimbing, debarking and chipping of the pulpwood was undertaken. The "semi-permanent" central landing was large enough to stockpile several days' wood supply for the Forest King.

Tree length pulpwood was unloaded and stacked by a Caterpillar 950 rubber-tyred front-end loader. While chipping, the Forest King moved as required along the face of the stockpile. The debris from the flail-chipper was cleared by the wheeled loader, and about twice a week loaded by a front-end bucket loader on to dump trucks for use in the forest as fill or for surfacing landings.

STUDY METHOD

Productivity Analysis

Activities on the central landing were timed for three operating days, and analysed to obtain productivity and utilisation information. These results were compared with previous measurements made of the Forest King while it was processing radiata thinnings in a mobile operation moving between landings (Franklin,1991). Chip samples were collected and analysed for bark content and chip size distribution.

Age/Stem Treatment Trials

Four age/stem treatment trials were undertaken, consisting of 18 and 28 year old topped and partially-delimbed pulpwood, and 18 and 8 year old full stems.

Partially delimbed stem trials :
18 and 28 year old radiata pine

Pulpwood from the local 18 year old clearfell operations was the standard product processed by the Forest King, so constituted the major part of the study. This material had all been topped, and had only 5-15% of the limbs remaining by the time the stems reached the central landing (Figure 2). This "tree-length" material averaged 0.33 tonnes per piece.

Figure 2 - 18 year old Tree Length Pulpwood

Some 28 year old radiata clearfell was delivered to the processing site for debarking and chipping, so the opportunity to measure the results from this sized material was also taken.

Full Tree trials :
18 and 8 year old radiata pine

As the potential delimbing capacity of the chain flail had not been tested in the earlier trials, a sample of "full tree" material from the 18 year old clearfell was processed through the Forest King. The "full trees", averaging 20 metres in length (13-23m range), had not been delimbed or topped, but the butt log had been removed from any oversized stems. They were trucked to the flail-chipper in standard log trailers and unloaded at the central landing.

Similarly, 3 truck loads of "full tree" material averaging 0.12 tonnes per tree from an 8 year old "waste" thinning operation were recovered by skidder and delivered to the Forest King for processing.

Fibre Recovery Analysis

Measurements were made on all four of the above age/stem treatment trials to compare the total green weight of the material fed into the flail with the weight of the chips recovered from the chipper. For this test a Cat 936E wheeled loader, equipped with a Loadrite weighing device, was used to weigh the roundwood input. This was compared to the net weight of the chips collected in the chip vans via weighbridge results.

These analyses were made from four chip van loads each of the 18 and 28 year old pulpwood and from five loads of the 18 year old full trees. Only a partial load of chips was obtained from the 8 year old thinnings due to the longer time required to process this material.

RESULTS : MOBILE VERSUS CENTRAL PROCESSING

Production and Utilisation

The results of the time study at the central landing operation in March, 1991 are compared with a similar study one month earlier when the Forest King operated in the "mobile" mode (Table 1). The chip truck load size was smaller in the central landing operation because the cartage route to the mill included public roads.

The change from mobile to central landing operation resulted in an increase of almost 11% in daily production (265 to 293 tonnes per day). Productivity in tonnes per productive machine hour (PMH) increased by 24%, from 36 to 45 tonnes/PMH.

	Loads	Green Tonnes			Percent	
	per day	per load	per PHM	per SMH	Net Util	Mech Avail
Mobile operation (February, 1991)	9.0	29.4	36.7	30.0	49.9	91.3
Central operation (March, 1991)	12.0	24.4	45.4	33.2	60.3	86.4

Table 1 - Productivity of the Forest King : Mobile versus Central Operation

Data from Table 1 suggest that the chip production potential (i.e. 100% net chipper utilisation) is 55 tonnes per scheduled machine hour (SMH). Net chipper utilisation in this analysis is defined as the mean "load chips" time as a percentage of scheduled time. Net utilisation increased from 50% to 60% due to the change from mobile to central operation.

The distribution of work time, in terms of minutes per van load of chips, for the two operations was also compared (Table 2). In the mobile operation the "move chipper" element included both moving on landings and between landings. In the central landing operation, the "wait for truck" element included time spent waiting for log trucks as well as waiting for chip vans. Mechanical delays in the central operation included chipper knife changes.

The two main reasons for the reduction in total time per load (from 58 to 44 minutes), and hence the improvement in daily productivity between the mobile and the central landing operations are:

the elimination of the requirement for the Forest King to move between landings one or more times per day resulted in a significant reduction in productive time lost per load (11%).

	Mobile Operation		Central Landing	
	Min per load	% of total	Min per load	% of total
Load Chips	29.35	49.9	26.61	60.3
Operation Delay: Position Truck	2.35	4.0	1.03	2.3
Wait for Truck	8.16	13.9	3.02	6.8
Move Chipper	8.20	13.9	1.61	3.7
Personal Delay	5.64	9.6	5.86	13.3
Mechanical Delay	5.09	8.7	6.00	13.6
TOTAL TIME	58.79	100.0	44.13	100.0

Table 2 - Distribution of Flail Chipper Work Time

- The reduction in time waiting for chip vans (9%), through improvement in co-ordination between truck operators and the Forest King operator.

The large landing contributed to the reduction in time required to position chip trucks for loading. The use of a wheeled loader to unload the roundwood improved the presentation of the wood supply in comparison to skidder stockpiling in the mobile operation. The marginal increase in mechanical delay was attributed to the fact that knife changes were scheduled into the work shift at the central landing. During the mobile operation, this had taken place outside the work shift whenever possible. The reduction in both pulpwood piece size and chip truck load size between the two operations had no affect on daily production.

The cost impact of the short haul primary cartage and the addition of a loader to unload roundwood in the central landing operation will be discussed in a later report, which will compare in-field chipping and chip cartage, to roundwood cartage to a mill woodroom.

Chip Quality

Bark Content

Samples were taken from 35 chip van loads during the study in March, 1991. The mean bark content shows a statistically significant difference from the previous samples taken in December, 1990 (Table 3).

The difference is attributable to any or all of the following reasons:

1. Mobile operation (14 year old) (n = 51, 99% confidence level)	: 0.58% $\pm$ 0.12%
2. Central operation (18 year old) (n = 35,99% confidence level)	: 1.00% $\pm$ 0.23%

Table 3 Average Bark Content (%)

- Pulpwood piece size

  The pulpwood from the clearfell operation processed at the central landing was smaller in piece volume than the full tree thinnings processed in the mobile operation (0.33 tonnes versus 0.38 tonnes).

- Tree age

  Fourteen year old thinnings were processed in the mobile operation versus 18 year old clearfell pulpwood on the central landing.

- Season

  The effect of the "sap season" may have had more impact on bark results during December (mobile operation) than in March (central landing).

- Stockpiling period

  In the mobile operation, the thinnings were usually processed within a few days of being cut, whereas the clearfell pulpwood had been stockpiled for up to 1-2 weeks.

Combining the bark samples from the two studies gave an overall mean bark content for chips from radiata pine of 0.74%

±0.13% (n = 86, 99% confidence level). This is within the specifications of most New Zealand pulpmills.

Chip Size Classification

Four batches made up of samples from 12 truck loads of chips from the 18 year old pulpwood were processed through a Williams classifier to assess the chip size distribution (Table 4).

There was a 7% increase in the proportion of acceptable chips, from 74% to 81%, resulting from a reduction in the proportion of both overlength and overthick chips. This change cannot be attributed to the change in processing location but rather to the difference between chips of young radiata (i.e. 14 year old thinnings) versus chips from older radiata clearfell.

The chip classification was correlated with the timing of knife changes. Some of the data suggest that, in radiata pine, dull knives may produce less oversize chips than sharp knives.

RESULTS : IMPACT OF STEM AGE/TREATMENT

Productivity

The productivity of the Forest King for the various types of wood input is given in Table 5. The productive time to fill a vanload of chips was similar for the three production trials. Flail-chipper productivity ranged between 0.2 tonnes per minute for the pre-commercial thinnings to 1.0 tonnes per minute for the 18 year old full trees.

Chip Quality

There was some variation in chip size proportions from the different samples (Table 6). The oversize proportion ranged between 9% and 17% for the production trials with the percent accepts tending towards 89%.

	Mean Percentage by Size Class			
November/December 1990	Mobile Operation March 1991		Central Operation	
Overlength (> 32mm)	21.5		15.3	
Overthick (> 10mm)	3.1		1.6	
Overs, Total %		24.6		16.9
Preferred	62.5		71.8	
Small	11.6		9.5	
Accepts, Total %		74.1		81.3
Pins		1.1		1.4
Fines (< 3mm)		0.2		0.4
TOTAL %		100.0		100.0

Table 4 - Comparison of Chip Dimensions by Size Class

	18-yr-old pulpwood C/F	28-yr-old pulpwood C/f	18-yr-old full tree C/F	8-yr-old full tree thinnings
Piece Size (Tonnes)	0.33	0.37	0.64	0.12
Net Chipping Productivity (tonnes/min)	0.92	0.89	1.00	0.21-0.24 (est)
Minutes per 25 tonne load	27.3	28.2	25.1	105-120 (est)

Table 5 - Flail Chipper Productivity

	18-yr-old pulpwood C/F	28-yr-old pulpwood C/F	18-yr-old full tree C/F	8-yr-old full tree thinnings
Chip dimensions: Sample Size (loads)	12	3	6	1
Overs (%)	16.9	9.9	8.7	27.9
Accepts (%)	81.3	88.0	88.7	70.1
Pins (%)	1.4	1.6	1.8	1.6
Fines (%)	0.4	0.5	0.8	0.4
TOTAL (%)	100.0	100.0	100.0	100.0
Bark Content Sample Size (loads)	35	3	6	5
Percentage Bark	1.00	0.54	0.70	1.88

Table 6 - Chip Quality

Fibre Recovery

	18-yr-old Pulpwood C/F	28-yr-old Pulpwood C/F	18-yr-old full tree C/F	8-yr-old full tree C/F
Sample Size (loads)	4	4	5	part load
Roundwood Input (tonnes/load)	26.00	26.44	27.41	-
Chip Output (tonnes/load)	24.08	24.40	24.93	-
Debris (%)	7.39	7.72	9.05	18.3
Fibre Recovery (%)	92.6	92.3	91.0	81.7

Table 7 - Fibre Recovery

The results of the four different trials to measure roundwood input versus chip output for the various treatments are given in Table 7.

The partially delimbed stems had similar fibre recovery proportions, mainly illustrating the loss of the bark from the stems. The full tree material had a lower fibre recovery reflecting the additional loss of branches. The smaller 8 year old full tree stems had a significantly lower fibre recovery because of the larger proportion of branches at this young age.

DISCUSSION

Partially Delimbed Stems

Although actual chipping time is only marginally different between the age/stem treatments (3%), the 28-year-old pulpwood was more difficult to chip, at times requiring knife changes after 2 loads rather than the normal 6 loads per set. This material was not as "fresh" as the 18 year old pulpwood at times being 4-5 weeks old. Reduced moisture content increases the "difficulty factor" of in-woods chipping.

The problem of "carding" (or production of oversize chips) is much reduced with the 28 year old stems, down to 10% in the denser, older wood from the 17% experienced in the 18 year old stems. This resulted in a higher proportion of acceptable chips from the older wood (88% versus 81%).

Full Tree

The trial showed that the Forest King is capable of removing large dry and green limbs from radiata pine (Figure 3). The chip production rate increased from 0.9 to 1.0 tonnes per minute for the larger full tree material. After adaption, no special problems were observed in handling limbs through the debris discharge system.

Figure 3 - Debris from Processing 18 year old Full Tree material

Six samples from the chips produced yielded 0.7% bark content, which is about the average result overall to date. The oversize proportion was within mill specifications at 8.7%,and accepts averaged 88.7%.

During the loading, handling and cartage process, the tops were broken off more than half of the trees at around 7-10 cm stem diameter. The shortest pieces were around 13m long, the longest were about 23m, with the majority being 20m long. Some limbs were also broken off, but many 5 to 8 cm diameter branches remained attached. The 9% debris figure derived for the full tree material would no doubt have been higher if the full trees were presented to the chipper with all their limbs and tops intact.

Handling and cartage of trees in excess of 20 metres long however presented problems, such as impractical overhang, and mechanical failures with branches getting caught in air hoses, etc. These problems would need to be addressed if this system were considered an economic option.

Waste Thinnings (Full Tree)

The 8 year old stems were small, with an average butt diameter of 18 cm, and average input weight of less than 0.12 tonnes. In this trial, it took 24 minutes to process 48 trees. Extrapolating this production rate indicated that 105 to 120 minutes would be required to produce a 25 tonne load of chips.

The flail can remove the dry and green branches without problem. However, the debris discharge system in its present configuration on the Forest King cannot handle the volume of debris generated by processing radiata pre-commercial thinnings in full tree form. Figure 4 shows the accumulation of green foliage after only 40 trees or about 5 tonnes of chips were processed. Three or four trees would need to be handled at a time to enable competitive processing of this material. The system would be a realistic consideration if some pre-delimbing was done, or if the Forest King's debris discharge system was modified to handle the sheer volume of limbs.

Five samples measured for bark content averaged 1.9%. However, 26% of that total was isolated as cambium containing useable fibre. The proportion of oversize chips was almost 28%, further reinforcing the proposition that younger, low density radiata pine is subject to carding during chipping.

Figure 4 - Debris from Processing forty 8 year old Full Trees

Without major modifications to the debris removal system of the Forest King, "waste thinnings" cannot be productively converted to usable pulp chips. Additionally, the economics of such an exercise would require further investigation. At least 3 trailer loads of full trees would be required to generate a load of chips. Disposal of debris generated from flail chipping of "waste thinnings" would also be a major problem.

CONCLUSION

Mobile versus Central Landing Operation

The change to a central processing operation was driven more by a lack of adequate landing space than as a strategy to improve production. Chip production at a central landing has some advantages over a mobile operation which requires moving from landing to landing.

While the actual chipping productivity varied only slightly, total daily production was increased by 11% as a result of higher net chipper utilisation (i.e. reduced operational delays). Hourly production increased from 36 to 45 tonnes/PMH as a result of the move to central landing processing. The system worked smoothly, and truck scheduling problems have been virtually eliminated. Debris disposal remains one area for further improvement and this is the focus of further machine development.

Overall, the percentage of bark in the chips produced in March was just under 1%, compared to less than 0.6% achieved in December. It is the view of the developer of the Forest King that the time of year has a major effect on the ease of debarking. In his view it is much easier to debark and chip radiata in the "sap season" from spring till mid-summer, than at other times of the year (G. Perfect pers comm.).

The percent of oversize chips decreased from 25% to 17%, with a corresponding improvement in the accepts percentage. This was due mainly to the change in wood input between the two operations.

Age/Stem Treatments

Productivity did not vary much between the 3 production trials (0.9 - 1.0 tonnes per productive minute). Processing 18 year old full trees did not adversely affect chip production rate, in fact the actual chipping productivity rate was marginally higher than that achieved in "tree length" and larger diameter radiata pulpwood. The flail had no major difficulty handling dry and green radiata branches of 5cm or more in diameter, and the debris discharge system had no difficulty getting rid of the limbs.

The chip quality from full trees was excellent, with almost 89% in the accepts category, and bark content of only 0.7%. The trial illustrated that the Forest King is capable of handling full trees in terms of both production and quality of chips produced.

Fibre recovery studies indicated that the loss in weight after debarking was roughly the same for 28 year old radiata stems as for 18 year old trees harvested mainly for pulpwood (around 7.5%). The fibre recovery for 18 year old full trees showed that 91% of input weight was recovered as chips.

The trial processing 8 year old pre-commercial radiata thinnings showed that some pre-delimbing would be required to make such an operation viable. The oversize chip content increased in this young wood, and the high bark content in these chips would allow their use for kraft, but they would not be suitable for CTMP newsprint.

The concept of in-woods clean chip production is a new one for New Zealand, and this operation is still in development. With continual improvement to the operating system it is foreseeable that over 90% acceptable chips could be achieved on a sustained basis.

REFERENCE

Franklin, G. (1991) : "Introduction of a Flail Chipper to New Zealand", Logging Industry Research Association Report Volume 16, No. 6.

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